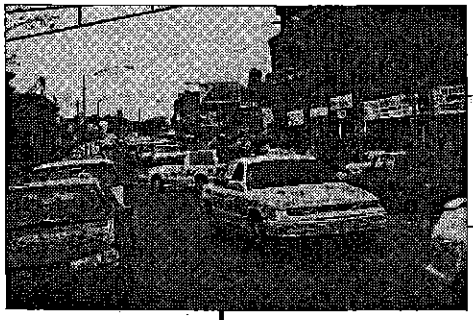
MBTA Bus Route 66
Arterial Improvement Study



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MBTA Bus Route 66 Arterial Improvement Study

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Introduction

BACKGROUND AND REPORT ORGANIZATION

The 1997 documentation of the Congestion Management System (CMS) performance monitoring and reporting[1] identified the MBTA Bus Route 66 as one of the routes most in need of improvements. Transit service evaluations conducted for the MBTA also recognized that Route 66 needed corrective action: both crowding and schedule adherence performance measures for this route were measured as poor. The CMS report recognized that one of the causes of the poor route performance was low levels of service for traffic flow on key arterials used by the bus route. Thus, the CMS report recommended conducting a study of the transit/arterial corridor.

The study consisted of developing an understanding of the existing conditions, both physical and operational, and analyzing alternative improvement measures. The following chapter of this report summarizes the existing conditions, including recent measures of route performance and of arterial street and intersection level-of-service. The subsequent chapter presents an overview of the recommendations of the study; for context, the report briefly reviews some of the analyses upon which the recommendations are based. The report concludes with a summary of the issues and recommendations, followed by some thoughts on implementation. The appendices include materials (such as technical memoranda) produced over the course of the study that document in more detail both the existing conditions in the study corridor and the study's analyses.

DESCRIPTION OF THE BUS ROUTE, STUDY CORRIDOR, AND ISSUES

Bus Route 66 travels on a series of major and minor arterials between Dudley Station at Dudley Square in the Roxbury neighborhood of Boston and Harvard Station at Harvard Square in Cambridge, via Brookline and the Allston-Brighton neighborhood of Boston. Being a circumferential route, this bus service crosses several other transit routes (bus and rail), providing multiple transfer opportunities. A map of the study corridor is presented in Figure 1. For a detailed description of Route 66, please refer to Appendix A pages 1 through 3. Included in the description are the hours of operation, frequency of service, and rider characteristics.

The bus encounters a series of impedances along its route. Route 66 is intersected by a number of major traffic routes that have heavier and priority movements. Forty of the intersections that the route traverses are controlled by a traffic signal. Lane obstructions resulting from commercial truck activity and improperly parked vehicles, are typically present along the route. Pedestrian conflicts are also common. All these characteristics contribute to numerous delays in the bus service, resulting in poor schedule adherence and, consequently, crowding.

[1] Central Transportation Planning Staff, for the Boston Metropolitan Planning Organization, *Mobility in the Boston Region—The Congestion Management System Annual Report for 1997: Existing Conditions and Next Steps*, February 1998.

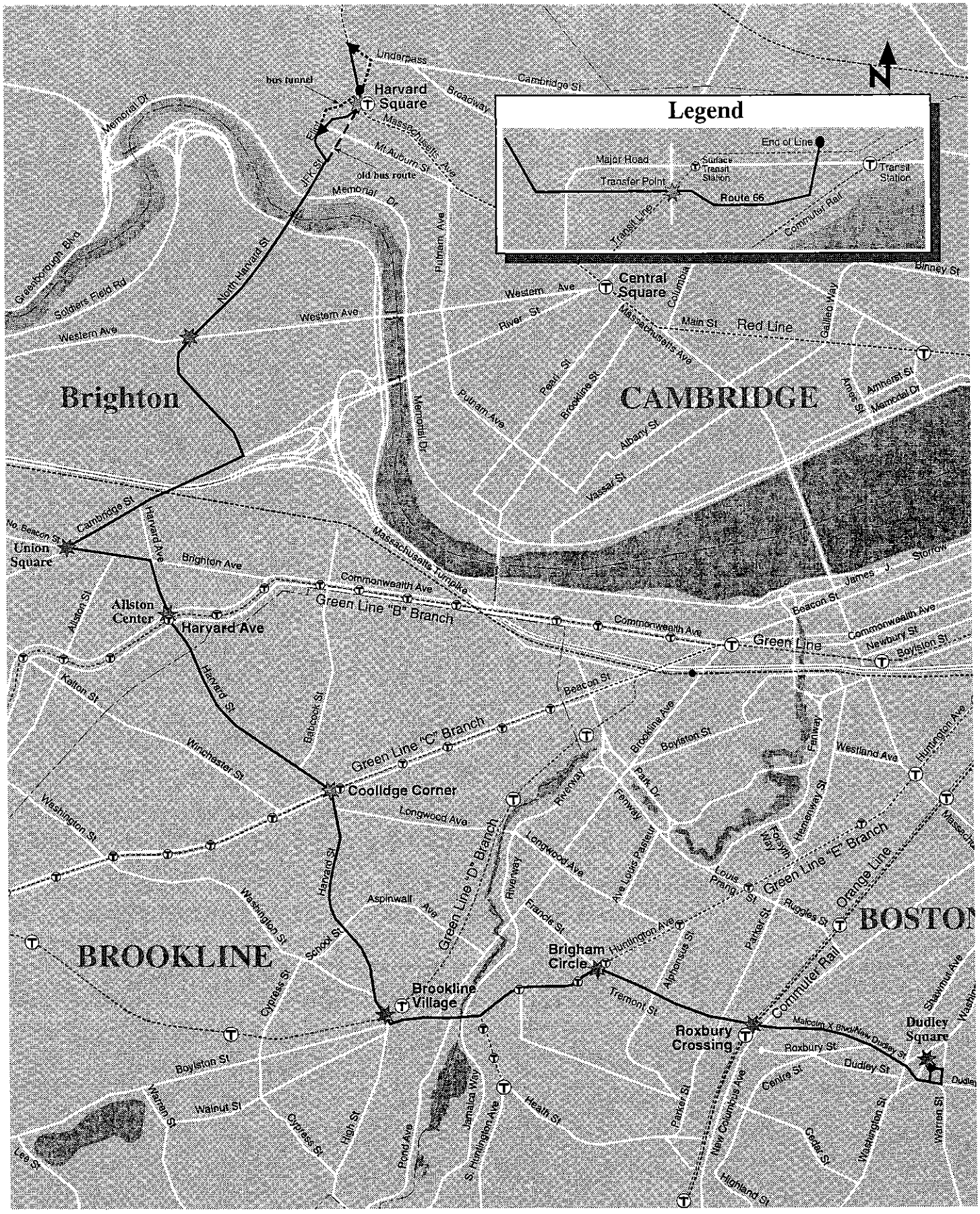
Averaging over 11,000 passengers per weekday, Route 66 is one of the most utilized bus routes in the MBTA system. The peak passenger volume occurs in the morning peak period on trips that depart from Dudley Station. Fifty percent of these northbound trips typically exceed the MBTA's passenger loading standard of 140 percent of seated capacity, based on past ridecheck surveys. In some cases, passengers were observed to remain standing for the length of the route due to the unavailability of seats. Southbound trips (departing from Harvard Station) in the morning were observed to lie within the loading standard. Evening trips in both directions, although crowded, also were observed to be within the standard.

Poor schedule adherence performance of the bus route, not the frequency of service (headways are as low as 9 to 10 minutes during the peak periods), is often the cause of crowded conditions. Observations of on-time performance indicate that most of the Route 66 bus trips do not arrive on time, despite on-time departures.[2] During the morning peak hours, over 70 percent of the trips failed to arrive on time. In the evening, 83 percent of the trips did not arrive on time. Even during the midday, 71 percent of the trips were observed to be off schedule.

The objective of this study is to identify the factors contributing to the undesirable performance characteristics of Bus Route 66 and to recommend potential improvement measures.

[2] *On-time* is defined in the MBTA's service planning assessment as: departing on the scheduled time or within 5 minutes past the scheduled time (no early departures), and arriving at the scheduled time or within 5 minutes past the scheduled time (no early arrivals).

Figure 1
Study Corridor
MBTA Bus Route 66 Arterial Improvement Study



Existing Conditions and Performance

This section presents the observations from the data collection efforts for the various performance measures. Both the bus service and the conditions along the arterial corridor were investigated.

BUS SERVICE

Two sets of ridecheck data and a set of timecheck data provided the foundation for the bus service analysis. The ridecheck data provided both schedule adherence and ridership load information. The route was observed as part of the Comprehensive Ridecheck Program in the spring of 1996 (Round I) and the winter of 1997 (Round II). The timecheck data provided information on schedule adherence and bunching conditions. The surveys were conducted on three days in April 1998 during the morning peak travel period (7:00 a.m. to 9:00 a.m.), the midday period (11:30 a.m. to 1:30 p.m.), and the evening peak period (4:00 p.m. to 6:00 p.m.). Departure and arrival time data were collected at the two endpoints (Harvard Square and Dudley Square) and at three intermediate points of the route (Brookline Village, Coolidge Corner, and Commonwealth Avenue).[3]

Appendix A provides a detailed description of the Bus Route 66 service operations, including ridership characteristics and schedule adherence. The following is a summary.

Schedule Adherence

Schedules for bus routes are set to reflect the running times under the conditions prevalent in the route's corridor. Hence, to a certain extent, schedule adherence is a function of how the schedule is defined for a particular route. Yet, a number of factors—particularly traffic-related—contribute to a bus's running time. For instance, traffic signal delay, parking conditions, and pedestrian activity all contribute to bus schedule adherence problems.

Schedule adherence information was gathered and documented as part of the study effort. The performance breakdown is presented in the "Schedule Adherence" section of Appendix A for weekday service (both peak and non-peak periods), Saturday service, and Sunday service. Observers found that the time the buses take to complete their trips is highly variable.

Bus Route 66 operates with peak period headways of 9 to 10 minutes and midday headways of 15 minutes. Scheduled trip cycles[4] range from 88 to 110 minutes, and average 100 minutes. The bus schedule design includes 12 to 16 minutes of layover time at the end of a one-way trip.

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[3] Since the data collection effort, the outbound path of Route 66 in the Harvard Square area has been changed from following JFK Street to Massachusetts Avenue through the square. Outbound buses now enter the bus tunnel via Bennett Alley. The effect of this change is assumed to have a negligible effect on the analysis and recommendations.

[4] A one-way trip consists of both *running time* and *layover time* and constitutes half of a *trip cycle*. The layover time is the period between the time a bus arrives at its destination and the time it is scheduled to depart for the return trip. Essentially, the layover time regulates the bus schedule; it provides time to absorb delays experienced on the prior trip, thus preventing a late departure of the next trip.

"Inbound" trips are those departing Harvard Square; "outbound" those departing Dudley Square.

Quite often, all of a trip cycle's scheduled layover time is used to absorb delays encountered by the bus, or the amount of delay exceeds the scheduled layover time. On the other hand, sometimes trip cycles have as much as half an hour of layover time when less impedance than usual is encountered. At present, substantial layover time is necessary due to the variability of the running times.

The variability of the running times for the bus within various time periods is investigated in detail in Appendix A. In the morning peak period, for instance, some one-way trips were observed to run as much as 14 minutes early and up to 13 minutes late. On average, though, inbound buses arrived 5 minutes later than scheduled (running times: about 14 percent longer), while outbound buses arrived 7 minutes later than scheduled (about 21 percent longer). The midday service performed better: the inbound service ran only slightly longer than scheduled, on average; the outbound service ran about 4 minutes late on average (about 11 percent longer). Inbound running times in the evening peak period varied between 31 and 57 minutes, averaging 6.5 minutes longer than scheduled (about 16 percent longer). Outbound evening peak trips were observed to vary between 30 and 65 minutes and averaged 8 minutes longer than the scheduled time (about 14 percent longer). The examination of Saturday and Sunday service is also detailed in Appendix A.

Appendix B shows the further investigation of existing bus performance conditions that can affect the variability of the running times, such as bus stop activity and delays experienced at intersections.

Ridership and Passenger Loading

Passenger loading (also referred to as passenger crowding) is another measure investigated as part of the study. The MBTA service policy includes standards for passenger loads, in order to maintain acceptable levels of service.[5] Based on ridechecks, Route 66 boardings and passenger loads are high in all the time periods on all days of the week. At several times in each service day, individual trips carry heavy passenger loads in which many passengers are forced to stand. Though the average load for the peak periods generally does not exceed the service policy standard, numerous individual trips within each peak period do experience crowded conditions. The "Loading" section in Appendix A further discusses the violations of passenger loading standards.

The segments of the route that typically carry the greatest passenger loads are shown in Table 1 below.

[5] The passenger load is calculated as the total ridership for the time period divided by the number of bus seats provided during the time period. The maximum passenger load standard for morning and evening peaks is 140 percent of seated capacity. On an individual trip this load standard translates to 40 seated passengers plus 16 passengers that would need to stand at the peak load point. The maximum load standard for midday trips is 100 percent of seated capacity. In this case, an individual trip would have a maximum of 40 passengers on board, with no one forced to stand.

Table 1. Bus Route 66 Segments with the Heaviest Observed Passenger Loads

Peak Hour	*Inbound*	*Outbound*
AM Peak Hour	From Union Square to Brookline Village	From Coolidge Corner to Soldiers Field Road and, occasionally, the entire route.
Midday Peak Hour	From Coolidge Corner to Roxbury Crossing	From Brigham Circle to Union Square
PM Peak Hour	From Harvard Square to Coolidge Corner	From Brigham Circle to Union Square

Appendix B contains further detailed information on passenger loading profiles. Included in this documentation is the ratio of passengers on board to number of seats on the bus following each bus stop. Across all time periods of the day, the peak load segment is between Brookline Village and Commonwealth Avenue. Furthermore, the crowding patterns show that a significant percentage of riders use the bus to travel from Brookline neighborhoods to Harvard Square in the morning peak, and return in the evening peak. Also, several crowded trip segments correspond to the portion of the route that experience the greatest travel delays, between Coolidge Corner and Harvard Square.

Bus Stop Placement

Bus stop placement is a key element affecting the efficiency of transit operations. The locations of bus stops influence the distribution of passenger volume and boarding and alighting activity. The frequency of bus stops also affects the delay faced by passengers. Investigating the bus stop spacing and passenger activity helps to point out improvements that can streamline the bus service.

The six-mile-long Bus Route 66 has 46 outbound and 47 inbound bus stops, varying in placement on the near side and far side of intersections throughout the route. The average bus stop spacing for the route is about 7 stops per mile or nearly 2 stops per quarter-mile—a generous spacing for a bus transit service. Roughly 60 percent of the route miles and 65 percent of the bus stops are in the two Boston neighborhoods, with an average of 8.3 stops per mile. The remainder of the route averages 6.7 stops per mile.

Boarding and alighting counts at the various stops indicate the most and least utilized ones. The greatest concentrations of boarding and alighting activity are at the termini and at the places where the route intersects the Orange Line and the Green Lines. In Roxbury and Brighton, where the bus stop density is higher than in Brookline, passenger use per stop is lower. Please refer to Appendix B, part C, which provides the counts of boarding and alightings by bus stop.

Passenger Delay

Passenger-hours of delay is essentially a measure of the passenger discomfort related to traffic congestion encountered by the bus during its run. In technical terms, this measure is the count of passengers on board a bus at an approach to a signalized intersection multiplied by the average seconds of traffic signal delay at the intersection approach.[6] This statistic places delay in terms of the number of persons affected, as opposed to simply vehicles. Passenger-hours of delay, a function of both passenger loads and signal delays, can serve as a baseline for measuring improvements in both passenger comfort and schedule adherence.

In this study, congested intersections identified via traffic operations analyses (described in the following section), were further analyzed for passenger-hours of delay experienced on Route 66. (Figure 2, which is provided at the end of this chapter, presents the congested intersections.)

For the inbound service, from Harvard Station to Dudley Station, the evening peak hour experiences the worst levels of passenger-hours of delay: almost twice the amount experienced in the morning peak hour. The intersections that have over three hours of passenger-hours of delay in any peak period are listed below, in order from north to south:[7]

- John F. Kennedy Street at Memorial Drive (intersection #52)
- North Harvard Street at Soldiers Field Road (#51)
- North Harvard Street at Western Avenue (#50)
- Cambridge Street at Harvard Avenue (#43)
- Harvard Street at Verndale Street (#37)
- Harvard Street at Aspinwall Avenue and School Street (#21)
- Washington Street at Boylston Street (#17)
- Huntington Avenue at Tremont Street (#10)
- Tremont Street at Parker Street (#6)

In the outbound direction of service, from Dudley Station to Harvard Station, all three peak hours experience high delays, but none as high as those experienced by the evening inbound service. Most notably, the intersection of Harvard Street with Aspinwall and School Streets stands out as the intersection with the highest levels of delay. (Apparently, the signal at Aspinwall favors the southbound and side street traffic over the northbound traffic, resulting in significant passenger-hours of delay for outbound passengers in all three peak hours.) Intersections with high (over three hours) outbound passenger-hours of delay are listed below:

- North Harvard Street at Soldiers Field Road (#51)
- North Harvard Street at Western Avenue (#50)
- North Harvard Street at Cambridge Street (#45)
- Harvard Avenue at Commonwealth Avenue (#38)
- Harvard Street at Stedman Street (#32)
- Harvard Street at Aspinwall Avenue and School Street (#21)
- Huntington Avenue at S. Huntington Avenue (#13)
- Tremont Street at Huntington Avenue (#10)

[6] Delay is also experienced due to impedances other than intersections. However, the delay caused by slowdowns and stops at intersections is the only measurable delay. Hence, passenger-hours of delay only refers to the delay experienced by the bus at an intersection approach.

[7] The intersection numbers, which are used throughout the report, derive from a consecutive numbering of all of the intersections of the route, from south to north.

- Tremont Street at St. Alphonsus Street (#8)
- Tremont Street at Parker Street (#6)

Detailed information on these observations can be found in Appendix B. Figures 5 and 6 of Appendix B illustrate the traffic signal–related passenger-hours of delay during each peak period for the inbound and outbound runs. Some of the intersections that experience high passenger-hours of delay at certain times of the day do operate at "acceptable" levels of service for vehicle delay. Such a characteristic is due to the high volume of passengers on certain buses coupled with moderate levels of service.

Appendix B also contains two tables (Tables 6 and 7) that list the inbound and outbound peak hour passengers on board at key intersections (those analyzed with Highway Capacity Software), the average delay faced by vehicles in the lane group the buses use, and the passenger-hours of delay for buses at the intersections.

ROADWAY CONDITIONS

Field Observations

A field reconnaissance of the route traversed by Bus 66 was conducted in order to understand, firsthand, the conditions of the corridor and identify potential problem characteristics and behavior. Overall, the reconnaissance provided observations that the entire corridor is significantly congested. In some cases, the congestion stems from heavy traffic volumes; in other situations, the signal timings and phase plans are not well adjusted to the traffic volumes by approach. Based on the observations, most of the signalized intersections seem to operate at a poor level of service at some point during the day. Failures at downstream signals often compound the problems at nearby upstream signals. In addition, throughout the bus route, parked cars are prevalent on both sides of the street, and parking even occurs in bus stop areas. Signing on several segments of the route are cluttered, potentially confusing drivers about parking restrictions. In these areas, double-parking in the travel lanes was observed to be a recurring problem. CTPS identified two commercial loading zones along the route, neither of which was located where the double-parking occurs.

A full description of the route reconnaissance is provided in Appendix C. Both quantified and subjective observations are included. The type of characteristics covered are: traffic volumes and congestion levels, traffic signal operation, intersection operation, parking, pedestrian and traffic safety, land use/activity, street design/geometrics, and street signage/striping. The observations are listed in geographic sequence by segment and intersection.

Roadway and Intersection Performance Analyses

As part of investigating the potential causes of schedule adherence problems of the Route 66 bus service, the performance characteristics of vehicular traffic along the route's arterials were studied. CTPS conducted two analyses of delay conditions: one used GPS-equipped vehicles to estimate travel time through the corridor (and to map the delay locations), the other used turning movement and signal timing data to estimate signalized intersection level-of-service based on the guidelines of the Highway Capacity Manual. Based on these two analyses a total

of 26 intersections were identified as operating under congested conditions. These are illustrated in Figure 2, which is provided at the end of this chapter.

Travel Time Runs

A sample of travel speed and segment delay measurements was collected via travel time runs. Based on the average travel speeds, the route was found to generally operate at arterial level of service (LOS) D throughout the day. The worst recorded levels-of-service occurred in the midday and evening peak periods, during which some segments operated under LOS F conditions. Figures 2 through 4 in Appendix D illustrate the measured speeds/LOS on the Bus Route 66 segments. Segment delay was used to identify "priority" intersections for a subsequent intersection LOS analysis (which is described below). These are listed in Tables 7 and 8 in Appendix D.

Intersection Performance Analysis

Following the identification of critical arterial segments and intersections on the route used by Bus Route 66 (based on the field reconnaissance, the travel time runs, and the passenger-hours of delay analysis), an intersection performance analysis was conducted. The analysis consisted of calculating the level of service for signalized intersections, as well as conducting a capacity analysis, for the weekday morning, midday, and evening peak periods. In addition, the impacts of traffic queues are also described and summarized. Please refer to Appendix E for the complete analysis.

Based on the analysis of intersection LOS, the following intersections were selected for improvement recommendations:[8]

- John F. Kennedy Street at Memorial Drive (intersection #52)
- North Harvard Street at Soldiers Field Road (#51)
- North Harvard Street at Western Avenue (#50)
- North Harvard Street at Cambridge Street (#45)
- Cambridge Street at Harvard Avenue (#43)
- Cambridge Street at Brighton Avenue (#42)
- Brighton Avenue at Harvard Avenue (#39)
- Harvard Avenue at Commonwealth Avenue (#38)
- Harvard Street at Beacon Street (#30)
- Harvard Street at School Street and Aspinwall Avenue (#21)
- Harvard Street at Washington Street (#19)
- Washington Street at Boylston Street (#17)
- Huntington Avenue at Tremont Street (#10)
- Tremont Street and New Dudley St. (now Malcolm X Blvd.) at Columbus Ave. (#5)
- Dudley Street at Warren Street (#1)

[8] The Harvard Street Rehabilitation/Improvements Project in the Town of Brookline implemented improvements to several intersections along Harvard Street between Beacon Street and Commonwealth Avenue. Completed during the course of this study, in 1998, this project included new signals at Verndale Street, Fuller Street, and Stedman/Williams Street. Hence, the study does not provide recommendations for those intersections.

Traffic Signal Control Systems

Information was collected on the traffic signal controls at the intersections along Bus Route 66 for use in identifying problems and possible improvements. Boston and Cambridge have centralized traffic signal control systems; Brookline has interconnected signals/closed-loop systems. These are illustrated and described in Appendix F, Section B.

Parking

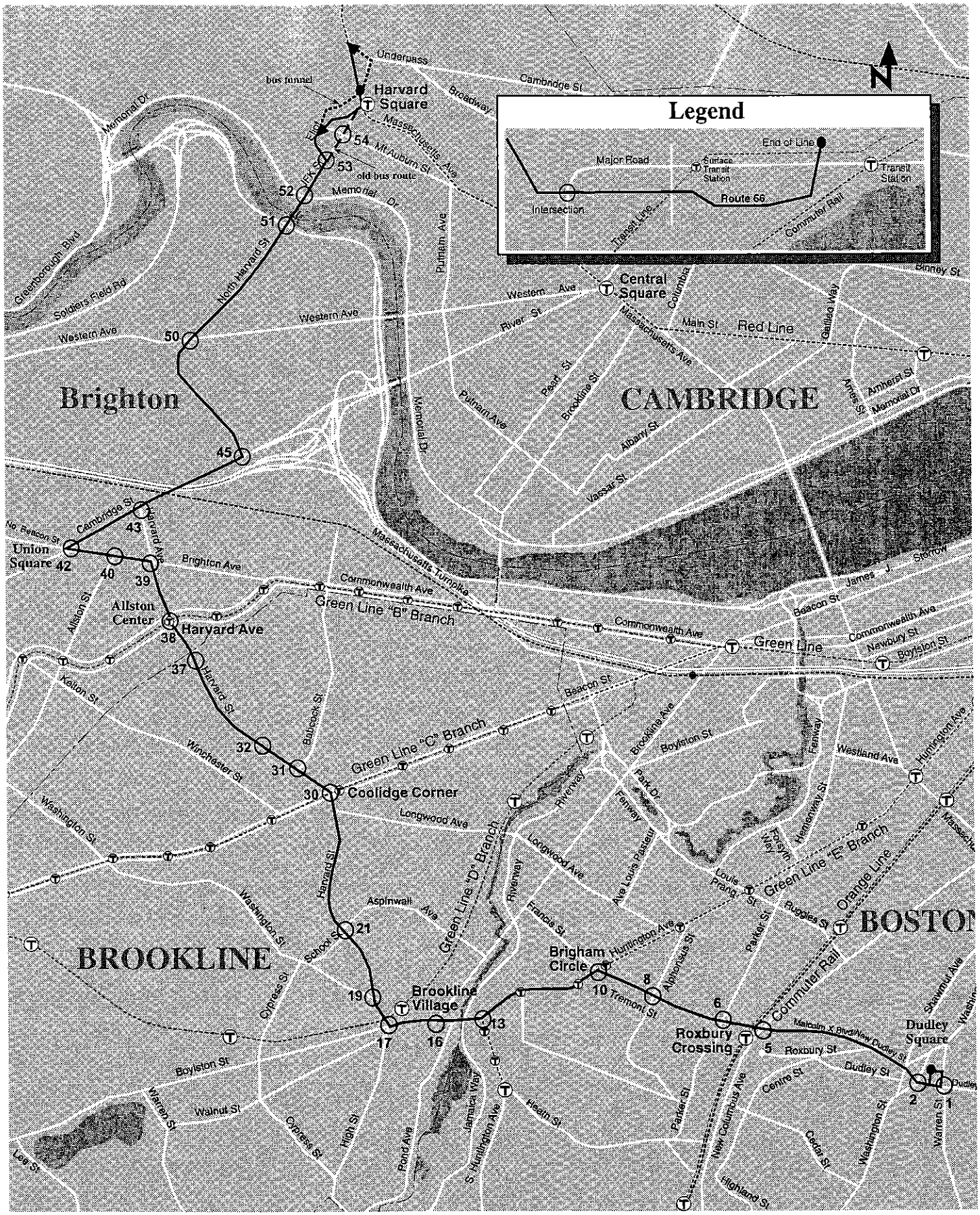
A major problem along the corridor is parking-related congestion. Throughout most of the route, parked cars are found on both sides of the street. Since many segments of the corridor provide access to local businesses, on-street parking is commonly provided. However, cars do not simply park in designated areas: many vehicles are found double-parked. Since Route 66 is in a commercial corridor and the supply of parking spaces is limited, truck drivers often double-park to load and unload vehicles. This behavior causes traffic to queue up, creating delays for the general traffic and failures in on-time performance for the bus.

Parking within intersection approaches and in bus stops are two other forms of illegal parking along the route that causes delay. Such parking behavior creates delays for turning vehicles and obstructs the movement of buses through intersections. In addition, when vehicles occupy bus stops, rider access to buses becomes difficult and unsafe. Furthermore, in situations where only one lane of traffic is available, buses that must stop outside of designated bus stop spaces cause delays to general traffic.

Poor pavement marking and signage also appear to contribute to motorist confusion regarding parking restrictions. This creates unnecessary traffic delays as drivers slow down and/or make additional vehicle movements.

The route reconnaissance described in Appendix C provides an inventory of the parking availability, restrictions, and signage/striping. Appendix F provides further detail of the parking situation encountered at specific locations along Bus Route 66, and discusses preliminary alternatives for improvement. Recommended actions are described in the following section.

Figure 2
Congested Intersections
MBTA Bus Route 66 Arterial Improvement Study



Recommended Improvement Strategies

This study's recommendations for improving Bus Route 66 service fall into three general categories: bus service, roadway/intersection, and parking. Recommended modifications and enhancements include bus schedule changes, bus stop relocation and consolidation, Intelligent Transportation System (ITS) applications, traffic signal timing, roadway geometrics, on-street parking restrictions, and commercial-vehicle loading restrictions. The last section of this chapter discusses the responsibilities for the implementation of improvements.

BUS SERVICE

In addition to parking and signalized intersection improvements, modifications to various aspects of the bus transit service itself are recommended. Described below, they include:

- changing the printed bus schedule, in order to reflect longer running times, due to the conditions along the corridor;
- increasing the frequency of service during particular periods,
- modifying bus stop locations, via elimination, consolidation, and relocation; and
- implementing adaptive traffic signal controls for bus priority.

An interim product of this study was a technical memorandum (see Appendix A) that included proposed recommendations for specific changes in Route 66 running times and headways. In the period of time between the transmittal of that memo and the release of the present, final report on this study, the MBTA has adopted a number of the recommendations made by CTPS in the memo.[9] The recommendations that outlined below are the outstanding recommendations from the memo.

Bus Operations

This study recommends adjustments to the scheduled running times for several time periods to improve schedule adherence. The adjustments are described below. (Time periods apply to weekday service, unless noted otherwise.)

- *Early MORNING Service (beginning of service – 6:59 a.m.).* In the outbound direction, the scheduled running time is inadequate for all trips starting later than 6:00 a.m. It is recommended that four minutes be added for trips between 6:10 a.m. and 6:50 a.m. to raise

[9] Service changes since September 1998:

- *Weekdays.* One bus has been added to both the morning and evening peak periods, as well as to the early afternoon. The running times, however, have remained the same. These additional vehicle assignments have slightly improved the scheduled headways.
- *Saturdays.* Running time and cycle time have been increased. Two additional buses have been added to the route; the headways have remained the same.
- *Midpoint.* For the purposes of internal timetables (used by the bus operators, not the general public), the route has been divided into two segments. The intent is to support schedule adherence to midpoint departure times at Union Square, in the Allston neighborhood. The printed schedule reflects this, showing a departure time for buses at Union Square, as opposed to an estimated midpoint arrival time as provided by previous printed schedules. This change was implemented in the fall of 2000.

the scheduled outbound running time from 26 to 30 minutes. Such a change would require alterations to the schedule, due to the relatively tight cycle lengths. No schedule changes are recommended for the inbound service.

- *Peak MORNING Service (7:00 a.m. – 8:59 a.m.).* In spite of the variation in morning peak running times, resetting the schedule to 42 minutes for both the outbound and inbound directions is recommended. This would provide a more reasonable average running time than the current scheduled times of 37 minutes for the inbound service and 35 minutes for the outbound service.
- *Early MIDDAY Service (9:00 a.m. – 11:29 a.m.).* Most observed outbound running times were longer than the scheduled times: six minutes longer, on average, in 1996. and three minutes longer in 1997. Based on the observations, the scheduled running time for this period should be increased from 36 minutes to 39 minutes. No schedule changes are recommended for the inbound service.
- *Peak MIDDAY Service (11:30 a.m. – 1:29 p.m.).* For outbound trips, it is recommended to increase the running time from 36 minutes to 39 minutes. This would reduce the number of late trips by seven and increase the number of early trips by seven (five of these would still be early by only one or two minutes). The scheduled inbound running time should remain the same. An additional vehicle should be brought into service, reducing headways to 14 minutes from 15 minutes and increasing the cycle time from 90 minutes to 98 minutes.
- *Late MIDDAY Service (1:30 p.m. – 3:59 p.m.).* In this period, the average running time for inbound trips was 47 minutes in both 1996 and 1997, six minutes longer than the scheduled running time. Enough inbound trips took more than 45 minutes to warrant extending the scheduled running time by at least four minutes to 41 minutes. No schedule changes are recommended for the outbound service.
- *Peak EVENING Service (4:00 p.m. – 5:59 p.m.).* Of the 38 inbound observations, 34 had observed running times greater than the scheduled 41 minutes and 25 of those had running times greater than the allowed 46 minutes. In the outbound direction, 27 of 36 observations had trip times greater than the scheduled 42 minutes and 19 of those had trip times greater than the allowed 47 minutes. The scheduled inbound running time should be increased from 41 to 47 minutes and the outbound running time should be increased from 42 to 48 minutes.
- *EVENING Service (6:00 p.m. – 8:59 p.m.).* In the inbound direction, the average running time observed in 1997 was 43 minutes, seven minutes longer than the 36-minute scheduled time; four trips took at least 50 minutes to complete their run. Although much variation occurred in the observed running times, and several trips in the 1996 ridechecks ran more quickly, extending the scheduled inbound running time to 40 minutes is recommended. Both sets of ridechecks suggest an extension of scheduled outbound running time from 35 minutes to 39 minutes.
- *NIGHT Service (9:00 p.m. – end of service).* The scheduled inbound and outbound running times should remain the same.
- *SATURDAY Service.* The main recommendation is to add a vehicle to the midday service, in response to the observed difficulties in meeting the schedule, and overall crowded conditions. This will permit headways to be reduced from 15 minutes to 14 minutes and increase the cycle time from 90 minutes to 98 minutes. Adjustments to the scheduled running times for all periods of the day are also recommended, as shown in Appendix A, Table 8.

- *SUNDAY Service.* Adjustments to the scheduled running times are also recommended, as shown in Appendix A, Table 9.
- *Overall.* Enforcement of schedule adherence needs to occur, especially at the recently established midpoint at Union Square.

Bus Stop Consolidation/Relocation/Elimination

As noted earlier, the frequency of bus stops on Route 66 is high, particularly in the Boston neighborhoods. The basic improvement strategies related to bus stops include: consolidation, relocation, and elimination of stops. The individual recommendations are based on the assessment of boardings and alightings at stops and on the arterial improvements that address traffic and parking issues. In general, closely-spaced stops with light activity should be considered for consolidation with other stops.

By adjusting bus stop placement, schedule adherence can be improved while maintaining good access to the bus service. Moreover, relocating stops that are very close to intersections where the bus must turn left would improve the traffic weave the buses must make to accomplish the turn. Another benefit of eliminating bus stops is the creation of space that can be used to establish commercial loading zones, especially in high-activity areas.

The recommended bus stop location strategies are:

Inbound

- *North Harvard Street at Western Avenue.* Relocate the stop further north. This would allow for the creation of a second lane for right turns at the intersection.
- *Cambridge Street.* Either the Royal or Franklin Street stop between N. Harvard Street and the Mass Pike overpass can be eliminated via consolidation. Another stop between the Mass Pike overpass and Union Square can be eliminated by consolidating two stops.
- *Harvard Street at Longwood Avenue.* Replace two parking spaces with a new stop just south of Longwood Avenue on the southbound side of Harvard Street. This would greatly facilitate the southbound left-turning movements as well as the through movements on Harvard Street at Longwood Avenue.
- *Harvard Street at Aspinwall Avenue.* North of the intersection, near Vernon Street, relocate the southbound bus stop further north, closer to the entrance to the Stop-and-Shop establishment. On southbound Harvard Street, move the bus stop to the far side of the intersection.
- *Huntington Avenue, west of Wait Street.* This low-activity bus stop can be eliminated.
- *Tremont Street.* One stop can be eliminated via consolidation between Huntington Avenue and Columbus Avenue.
- *New Dudley Street (Malcolm X Boulevard).* One stop can be eliminated in this segment between Columbus Avenue and Washington Street via consolidation, while keeping the Madison Park High School stop.

Outbound

- *New Dudley Street (Malcolm X Boulevard).* Between Washington Street and Columbus Avenue One two stops can be eliminated via consolidation, although the Madison Park High School stop should be kept.
- *Tremont Street.* One stop can be eliminated via consolidation between Columbus Avenue and Huntington Avenue.
- *Tremont Street at Huntington Avenue.* Relocate the northbound stop on Tremont to a position south of Worthington Street. This change would allow more travel room and the creation of a commercial loading zone.
- *Harvard Street at Aspinwall Avenue.* Relocate the northbound stop to the near side of Aspinwall Avenue by relocating or eliminating two or three parking spaces.
- *Harvard Street at Beacon Street.* Combine this bus stop with the stop north of the intersection between Beacon Street and Babcock Street. On the approach to Beacon Street, relocate both the bus stop and the Elderbus stop between Beacon Street and Longwood Avenue to the near side of Longwood Avenue. This should help the traffic flow at both the intersection with Longwood Avenue and with Beacon Street.
- *Harvard Avenue at Brighton Avenue.* Relocate the outbound bus stop on Harvard Avenue northbound farther south of Brighton Avenue. This would provide the buses with more room to merge to the left before making the left turn onto Brighton Avenue.
- *Cambridge Street at North Harvard Street.* Relocate the northbound stop away from the intersection. This would provide room for the bus to merge across three lanes of traffic for the left turn onto North Harvard Street. Alternatively, instead of simply relocating the stop, consolidate this stop with the one at Linden Street.
- *North Harvard Street.* One stop can be eliminated along the segment between Cambridge Street and Western Avenue. Another one can be eliminated along the segment between Western Avenue and the Larz Anderson Bridge.

Adaptive Traffic Signal Control for Transit

Another strategy to consider is the use of adaptive signal control (also known as signal preemption or traffic signal priority). Bus vehicles equipped with automated vehicle-locator (AVL) devices could communicate with traffic signals along the route in order to obtain favorable green time. Transit services in other cities have implemented this Intelligent Transportation System technology with notable success, obtaining improved schedule adherence, enhanced bus transfer coordination, and increased accuracy in schedule adherence monitoring and reporting, among other benefits.

A two-step approach to implementation should be considered for this corridor. The first step would entail permitting a few signals to extend green time for only those buses that are running behind schedule, when the transit vehicles need the travel time benefit. Buses that are running on time or ahead of schedule would be subject to the normal operating conditions. The second step, if the first implementation step works appropriately, would have the purpose of improving the overall running time of the Route 66 buses in general. In this step, on a trial basis, traffic signal priority would be given to all Route 66 buses and at most of the traffic signals in the corridor.

The use of adaptive traffic signal control may not be feasible at intersections with critical arterials. In many instances, the bus travels on the minor approach, crossing major transit corridors and high-volume roadways. Extending green times for the minor approaches could cause excessive delays for the major, more heavily-traveled approaches. Plus, many of the traffic signals along the corridor are part of coordinated signal systems. In these cases, changing the timing for one signal would mean that changes would need to be made to the other signals in the system. This could create added delay.

Isolated traffic signals (those not connected with other signals) are the strongest candidates in this corridor to accommodate signal preemption for transit. In the segments of the route in which the bus travels on the major approaches, some traffic signals that are part of a coordinated system could also be appropriately equipped. In any case, caution would need to be exercised to avoid adverse effects on cross street traffic.

An examination of the potential use of adaptive traffic signal control in the corridor should be conducted. A thorough analysis is called for, as traffic coordination through the area is complex. In addition, the implementation of ITS technologies in both transit vehicles and traffic control equipment would be involved due to the dual jurisdiction of transit authority and signal operator. The MBTA is the agency that is most appropriate to lead this effort. This ITS application should be considered as a possible accompaniment to the MBTA's adoption of AVL technologies.[10]

For a more complete description of adaptive traffic signal control for transit, please refer to Appendix H.

INTERSECTIONS

Recommendations for improving the route's intersections are presented below, proceeding in the inbound direction along Bus Route 66, from Cambridge to Boston. (The intersections are shown in Figure 2. The intersection numbers (in parentheses) derive from a consecutive numbering of all the intersections on the route, starting at Dudley Square.) The recommended intersection improvements focus on signal timing changes, signal coordination, lane restriping, and changes in parking practices.

In general, any signalized intersection that has a leading-green phase, a green arrow should be included in the appropriate signal heads to make it clear to drivers when they have a protected left turn.

Regarding pedestrian crossings, any recommendation is based on a set of principles that address the tradeoffs between vehicle delay and pedestrian mobility.[11] The recommendations

[10] The MBTA has plans to test AVL deployment on a select number of routes. The CT (crosstown) bus routes have been identified as candidate routes for AVL, and the Silver Line Bus Rapid Transit system is being designed to use AVL technology. Thus, these corridors are also potential routes for the testing of adaptive traffic signal controls.

[11] For many of the congested intersections along this route, it is impossible to change the allocation of green time in order to achieve an acceptable level of service (LOS) D or better while maintaining a full

discuss at which locations the removal of exclusive pedestrian phases is necessary to improve the LOS and which locations concurrent phasing or actuation seem to be most appropriate.

Intersection improvement recommendations are not presented for the congested intersections along Harvard Street between Beacon Street (Coolidge Corner) and the northern Brookline-Boston townline, since these intersections have recently undergone improvements.

Recommendations

John F. Kennedy Street at Memorial Drive (#52)

The existing vehicle volumes are not high enough to warrant turning one of the two existing lanes on each approach into an exclusive left- or right-turn lane. Retiming the signal to optimize operations at a 100-second cycle length would still result in LOS F for the morning and evening peak periods and LOS D for the midday peak (even with the recent removal of left turns from Memorial Drive at this intersection[12]). Nevertheless, signal retiming would still greatly improve the vehicle flow. A pedestrian phase of 20 seconds is built into every cycle, so there is no need for pedestrian actuation to accommodate the high pedestrian volumes. There would probably be further improvement at this intersection if there were signal coordination with the North Harvard Street at Soldiers Field Road intersection, but that was not evaluated. Aside from that, any additional improvement at this location would require either the elimination of left turns from JFK/North Harvard Street or a major redesign of the intersection.

Recommendations

1. A pretimed cycle length of 100 seconds should be set for this intersection and for the intersection of North Harvard Street at Soldiers Field Road (# 51), and the two signals should be coordinated along JFK/North Harvard Street.
2. In almost every cycle, some drivers ignore the left turn prohibition from Memorial Drive onto JFK/North Harvard Street. Since prohibiting these left turns greatly

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pedestrian phase that becomes actuated more than a few times during the peak hours. To obtain LOS D for vehicles, all pedestrian movements must be concurrent. However, concurrent pedestrian movements present some safety concerns, especially for children and the elderly. Since we did not collect pedestrian counts at any of these intersections, we cannot know precisely how heavily they are used. However, based on the average signal timings found in the field observations, pedestrians use the actuation buttons during at least one in ten cycles during the peak hours.

In the tradeoff between pedestrian safety and vehicle delay, the following three general principles are applied:

1. Concurrent pedestrian phases are appropriate at commercial intersections, particularly near non-essential commercial establishments. (An example of such locations are in the commercial area of bars and restaurants—places not often frequented by children and the elderly—that surround the Harvard Avenue at Cambridge Street and Harvard Avenue at Brighton Avenue intersections.)
2. Pedestrian actuation is more appropriate for intersections in residential neighborhoods or near a school.
3. When an intersection warrants pedestrian actuation, it should be limited to the "most hazardous" crossing. "Most hazardous" refers to the widest street or the streets with the most traffic turning onto them during the concurrent phase.

[12] The Metropolitan District Commission (MDC) recently prohibited left turns from Memorial Drive onto JFK/North Harvard Street from 7:00 to 9:00 a.m. and from 4:00 to 7:00 p.m.

improves operations at this intersection, better enforcement of this prohibition is necessary.

North Harvard Street at Soldiers Field Road (#51)

Currently, this intersection, as well as most of its approaches, operates at unacceptable level of service during all three peak periods. Changing the lane configuration and traffic signal phase design, as described below, including the retiming of the signal to a 100-second cycle length, would allow the intersection to operate at an acceptable LOS during all three peak hours.

The left-most North Harvard Street southbound lane is a de facto left-turn lane, and striping it to reflect that use would improve operations. A sign would also be needed on the southbound approach to describe the lane designation. In addition, the area where parking is prohibited during peak periods at the North Harvard Street northbound approach should be striped to indicate that it can be used as a right-turn lane during those times.

Recommendations

1. Currently, the Soldiers Field Road ramps are semi-actuated, with a cycle length of 90 to 150 seconds. A cycle length of 100 seconds, coordinated with the JFK/ Memorial Drive intersection, would improve operations at both intersections.
2. Restripe the de facto left-turn lane on North Harvard Street southbound and add a left-turn arrow for the green southbound phase. Stripe a right-turn lane on North Harvard Street northbound in the extended no-parking zone.

North Harvard Street at Western Avenue (#50)

All approaches currently operate at LOS F in all three peak periods, and a signal retiming cannot significantly improve the intersection's operation. Prohibiting parking (currently allowed) on all four approaches and restriping each approach to two lanes would allow all approaches to operate at LOS D or better in all three peak periods. If removing parking on all approaches is not feasible, removing parking on only the North Harvard Street approaches used by the Route 66 bus, both northbound and southbound, would result in LOS E or better for North Harvard Street in the morning and midday peak periods, although all approaches would remain at LOS F for the evening peak period. Converting the pedestrian-only phase to concurrent pedestrian movement would allow North Harvard Street to operate at LOS D in the evening peak.

Recommendations

1. Eliminate parking along North Harvard Street southbound near the intersection (about five or six spaces), at least during peak periods, and restripe North Harvard Street for two shared lanes in both directions.
2. Move the bus stop location on North Harvard Street southbound further from the intersection, to allow use of the right lane.
3. Eliminate pedestrian actuation and restrict pedestrian crossings to concurrent phases, since little pedestrian activity was observed in this area.

North Harvard Street at Cambridge Street (#45)

Cambridge Street eastbound left turns fail during all three peak periods, and problems with southbound left turns from North Harvard Street were also observed. Eliminating the leading-green phase on Cambridge Street eastbound and allocating more green time to the North Harvard Street and Cambridge Street exclusive-left phases would allow all movements to operate at LOS D or better.

Recommendations

1. Eliminate the leading-green phase for eastbound Cambridge Street.
2. Allocate more green time to the North Harvard Street and Cambridge Street exclusive left-turn phases.
3. Relocate the bus stop on eastbound Cambridge Street further back from the intersection, or combine it with the stop at Linden Street, to facilitate the merging of buses into the left-turn lane to North Harvard Street.

Cambridge Street at Harvard Avenue (#43)

Left turns from Cambridge Street westbound and right turns from Harvard Avenue northbound fail in all three peak periods, and other movements fail on occasion. Removing the pedestrian phase and allocating more green time to the Cambridge Street westbound leading-green phase would allow all movements to operate at LOS E or better during all three peak periods; however, this would create an unsafe crossing for pedestrians due to the heavy left-turning movement.

Improvements at this intersection would require that changes be made to accommodate traffic at Brighton Avenue/Harvard Avenue as well. One of the biggest problems on Harvard Avenue southbound is the lengthy queue extending from Brighton Avenue, and any increase in throughput here will only increase that queue.

Recommendations

1. Allocate more green time to the westbound Cambridge Street leading-green phase (left-turn arrow).
2. Remove three to four on-street parking spaces on Harvard Avenue northbound to allow unobstructed right turns (from Harvard Avenue) during the Cambridge Street westbound leading-green phase and provide a right-turn arrow for that phase.

Cambridge Street at Brighton Avenue and North Beacon Street (Union Square) (#42)

Left turns from Cambridge Street northbound to North Beacon Street westbound are prohibited, but more than 30 of these left turns were counted during each peak hour. Analysis showed no LOS problems for any peak period.

Traffic queues from the signal on North Beacon Street at Everett Street frequently back up into this intersection. The Everett Street intersection is currently in the Brighton Avenue local coordination network. The problem is that this network has a different coordination strategy from the Cambridge Street network.

Recommendations

1. Provide clearer signage for and enforcement of the left-turn prohibition.
2. On the westbound side of North Beacon Street, either provide yellow curb markings that prohibit parking, thus removing a few parking spaces, or enforce the current prohibition during evening peak hours. This should allow better merging of traffic.[13]
3. Because snow and ice frequently obscure curb markings, install a sign stating "No Parking Any Time" (MUTCD sign number R7-1). Provide enforcement of the no-parking restriction.[10]
4. A coordination network integrating all the intersections in this area should be created.

Brighton Avenue at Harvard Avenue (#39)

Changing to a concurrent pedestrian phase with a leading left-turn phase on Brighton Avenue and more green time on Harvard Avenue would produce LOS D or better for the morning peak period, but Harvard Avenue southbound would still fail in the evening peak. Adding a leading-green phase with a left-turn arrow for Harvard Avenue southbound would enable all movements to operate at LOS D or better in both the morning and evening. Currently, drivers on Harvard Avenue making left turns, both northbound and southbound, are trying to occupy the same space, and they need to be separated. Queues from this intersection currently extend along Harvard Avenue to Cambridge Street.

Recommendations

1. Eliminate the exclusive pedestrian phase and the actuation buttons. This commercial area is an appropriate location for concurrent phasing.
2. Restripe Harvard Avenue to provide left-turn storage bays of 100 feet in both the northbound and southbound approaches. This will require four on-street parking spaces to be removed on each approach. Also, the bus stop on northbound Harvard Avenue would have to be moved further south to allow the Route 66 bus to get in the left lane.[10]
3. Add a leading-green phase with a left-turn arrow for Harvard Avenue southbound, within the existing 110-second cycle (in order to maintain coordination along Brighton Avenue).[10]
4. Signal coordination in this area is along North Beacon and Cambridge Streets. Coordination along Harvard Avenue might be more effective, and should be studied.

Harvard Avenue at Commonwealth Avenue (#38)

A major redesign of the intersection has recently been completed. The design includes relocation of the MBTA tracks to the center of Commonwealth Avenue and other changes that

[13] The *Route 20 Transportation Planning Study* [Asante, S. *Route 20 Transportation Planning Study*. Central Transportation Planning Staff, May 1998] also recommends this improvement.

should improve operations. Under these circumstances, the recommendations focus on signing and striping to improve the traffic flow at this intersection.

Recommendations

1. All right turns from Commonwealth Avenue to Harvard Avenue should be made from the frontage roads rather than from Commonwealth Avenue itself. This would require that signs be located at least one intersection "upstream" on both Commonwealth Avenue and the frontage roads, alerting drivers to this requirement.
2. Left turns from the frontage roads are prohibited, but the only signs are at the intersections. Again, signs with the proper directions should be added at least one intersection upstream.
3. On Harvard Avenue, both northbound and southbound, conflicts between left-turning and through vehicles take place at numerous points within the intersection. Striping the paths for the left and through vehicles should greatly reduce the number of conflict points.
4. Signs for the businesses and addresses along each section of the frontage road, again upstream from where the frontage roads need to be entered, would help reduce confusion and the excessive number of U-turns that occur in this area.

Harvard Street at School Street and Aspinwall Avenue (#21)

Removing the southbound leading-green phase and adding a third southbound lane (right turn only) would improve the evening peak LOS to D or E. However, the traffic operations during the morning peak still fail, because of the high volume of southbound and eastbound turning traffic. Eliminating the pedestrian phase and actuation buttons in order to improve intersection LOS is not desirable, since the vicinity consists of residences and schools.

Recommendations

1. On southbound Harvard Street, move the bus stop to the far side and reconfigure this approach to three lanes.
2. North of the intersection, near Vernon Street, relocate the southbound bus stop further north, closer to the entrance to the Stop-and-Shop establishment.
3. Allocate more green time to the southbound Harvard Street leading-green phase.

Harvard Street at Washington Street, Kent Street, and Davis Avenue (#19) (Brookline Village)

In both the morning and evening peak periods, Washington Street southbound and Harvard Street southbound operate at LOS F, and no simple retiming improves the rating for Harvard Street to LOS E. Since the Davis Avenue right turn can also take place during the Kent Street phase, no problems are encountered during the morning peak (when analyzed as an isolated intersection). During the midday peak, Harvard Street southbound remains a problem, but a simple retiming would probably solve the problem.

No counts were done for Kent Street. Observation suggests that too much green time is allocated for the number of vehicles using Kent Street.

If either the Kent Street or the Davis Avenue phase were removed, the intersection performance would improve: the morning peak would experience a LOS D, and only Harvard Street southbound would have a problem in the evening peak). However, due to the offset of the two approaches, a conflict in traffic movements will occur if these phases are combined into one.

To achieve LOS E or better during the evening peak would require removing some on-street parking so that either the Washington Street or Harvard Street southbound approaches could operate as two lanes near the intersection. Without adding some additional off-street parking in the area this might not be practical, although a peak-period ban might be feasible.

Finally, the Washington Street southbound green phase is currently coordinated with the southbound green phase at the next intersection, Washington Street at Boylston Street. As a result, the Harvard Street southbound traffic frequently backs up through the middle of the intersection, blocking the Davis Avenue movements and sometimes Washington Street as well. Since Harvard Street southbound always has heavier volumes than Washington Street, this coordination should be changed to favor Harvard Street southbound. This would also help Bus Route 66 at the expense of Bus Route 65 (however, the Route 66 bus runs much more frequently than the Route 65 bus).

Recommendations

1. Remove a few parking spaces (no more than five) on Washington Street or Harvard Street southbound, at least during the morning and evening peaks, to allow one of those approaches to operate as two lanes into the intersection.
2. Kent Street and Davis Avenue should have vehicle actuation, with the maximum green time set at no more than 10 seconds for Kent Street and 5 seconds for Davis Avenue.
3. Coordinate the Harvard Street southbound phase with the Washington Street southbound phase at the Washington Street-Boylston Street intersection. This might require some adjustment of the signal at Washington Street and School Street.

Washington Street at Boylston Street and High Street (#17)

Southbound Washington Street left turns fail in all three peak periods. Running a three-phase semi-actuated operation (for the Boylston Street, Washington Street, and High Street approaches) improves the intersection to LOS C while preserving the cycle length to allow coordination.

This signal timing plan includes the use of concurrent pedestrian phasing. Concurrent pedestrian phasing should allow safe crossing on High Street and on Washington Street, as long as the right turns from westbound Boylston Street are prohibited during the Washington/High Street phase. Pedestrian actuation is recommended for Boylston Street, since it has the widest pedestrian crossing of the approaches. Since the intersection operates at LOS C for all three peak periods, an occasional pedestrian actuation would not significantly disrupt vehicle flow.

Making the Washington Street southbound right-turn lane exclusive and creating an exclusive southbound left-turn lane and a shared left/through lane would help to clear out Brookline Village traffic, and still improve the operation of the intersection.

Recommendations

1. Run the signal as a three-phase, semi-actuated operation. Prohibit right turns from westbound Boylston Street during the northbound High Street phase.
2. Use concurrent pedestrian phasing on Washington Street and High Street, and allow pedestrian actuation on Boylston Street.
3. Restripe Washington Street southbound to create these three movements: an exclusive right-turn lane, a shared through and left turn lane, and an exclusive left turn lane.

Huntington Avenue at Tremont Street and Francis Street (#10)

In terms of signal timing, the only way to reduce traffic delays encountered by the bus is to allocate a few more seconds of green from Huntington Avenue to the Francis Street-Tremont Street phase.

Recommendations

1. Re-time the signal to provide more green time to the Tremont Street-Francis Street phase.
2. Address the frequent double-parking at this location.

Tremont Street at New Dudley Street (Malcolm X Boulevard) and Columbus Avenue (#5)

Northbound Columbus Avenue left turns operate at LOS E or F during the morning and evening peak hours; eastbound Tremont Street and westbound New Dudley Street operate at LOS E during the evening peak. Signal retiming for the morning or evening peak traffic does not improve level of service, according to the analysis. Pedestrian congestion in the area is very pronounced at the end of the school day.

Recommendations

1. Extend the signal coordination along Tremont Street to include all the intersections between Roxbury Crossing and Brigham Circle.
2. Improve safety by deploying police and/or school crossing guards at the end of the school day to minimize pedestrian-vehicle conflicts.

Dudley Street at Warren Street (#1)

While LOS calculations show some problems, they are based on legal lane use. Currently, frequent double parking blocks many of the legal lanes. Parking enforcement is a problem, but the frequent double-parking indicates that demand exceeds supply in the area. Lack of adequate parking and poor striping of the existing lanes are responsible for many of the problems in Dudley Square.

The high demand for on-street parking at Dudley Square indicates a grave need for public off-street parking. Enhanced enforcement of parking restrictions is not enough. Once the parking situation improves, other traffic-related problems can be appropriately analyzed and mitigated.

Recommendations

1. Locate a site for an off-street parking garage and begin construction as soon as possible.
2. On the pavement at the Dudley Street westbound approach to Washington Street paint channelization arrows and stripes to provide three lanes: a left-turn lane, a shared left- and through-lane, and a through-lane.
3. Restripe the Dudley Street eastbound approach to Warren Street to reduce the number of lanes from three to two, eliminating the right-most through lane adjacent to the free-right-turn lane. (The eliminated lane appears to be unused; if this lane were used, queues in it would block the eastbound right turns onto Warren Street.) Extend the existing pedestrian island into the space created by elimination of the lane.
4. Limit pedestrian crossings at the Dudley Street eastbound right-turn lane to occur only during the pedestrian-actuation phase, and allow these right turns from Dudley Street during all other phases.
5. Stripe and channelize Warren Street to create a left-turn and a through lane at the intersection with Dudley Street. Restripe the single Dudley Street westbound lane as two shared lanes for through and turning movements.

PARKING

As discussed in the preceeding section, traffic flow along the corridor is observed to be affected by parking conditions. The detailed description of the conditions at specific locations are given in Appendix F.

This study recommends both a long-term analysis of parking demand and alternatives as well as a short-term set of local improvements. These are listed below:

1. For long-term relief of parking-related delays, the recommendation is to **conduct a parking demand study** in order to assess the suitability of creating off-street parking facilities. Such a study would provide insight into the nature of the parking demand. The parking study should also conduct a turnover rate analysis to help quantify the volume. The Dudley Square area of Roxbury stands out as one location for the study of off-street parking.
2. In the short term, this study recommends the types of parking-related measures listed below, in order to help limit parking activity that interferes with traffic flow throughout the corridor.
    - **Increase enforcement of parking regulations** along the entire route. In particular, as much as possible:
        - Bus stops should be kept clear of parked cars.
        - Double-parking should not be allowed.
        - Loading/unloading should not be permitted outside designated areas.

- **Clearly mark reserved areas for commercial vehicles** in which loading and unloading may be done without blocking traffic. Critical business areas include Tremont Street in Roxbury and Harvard Avenue in Brighton. Also, local governments may want to consider expanding the available space for loading zones.
- **Better designate parking spaces** with pavement striping, parking meters, and well-defined parking restrictions. Opportunities to use curb extensions, such as neckdowns, for designating on-street parking areas should be explored.
- At several locations, **add parking meters to the existing parking spaces.** These mechanisms help to reduce confusion regarding on-street parking restrictions. Plus, money collected from parking meters could generate revenue for the acquisition of property or construction costs to build off-street parking facilities.
- **Remove parking for a short distance at intersection approaches.** This will free up roadway space so that a short lane or "pocket" may be created for turning vehicles. This strategy also improves the visibility of and for pedestrians wishing to cross the street at such points.

Specific Recommendations

The recommendations are addressed to the City of Boston, the Town of Brookline, and the City of Cambridge, which are the agencies responsible for implementation. An adequate public participation process should be conducted if local governments consider the removal of on-street parking spaces along the corridor. Local residents and merchants should be given the opportunity to express their thoughts and concerns regarding such measures.

Suggested improvement strategies, as detailed in Appendix F, are the following:

John F. Kennedy Street, Cambridge

- Identify appropriate locations for commercial loading reservations.
- Enforce parking restrictions to eliminate double parking

North Harvard Street at Western Avenue, Brighton

- Enforce parking restrictions.
- Look for an appropriate place to site an off-street parking facility.

Cambridge Street, Brighton

- Paint curbside parking spaces to delineate them from travel lanes, curb cuts, and bus stops.
- Define the parking limits (location and time periods).
- Add parking meters to the parking spaces.
- Paint bus stop bays at the bus stops to delineate them from parking spaces and curb cuts.

Union Square, Brighton

- Enforce parking restrictions.

- Look for an appropriate location to site an off-street parking facility.
- Eliminate parking spaces on North Beacon Street that are too close to the intersection.

Harvard Avenue between Cambridge Street and Commonwealth Avenue, Brighton

- Paint parking spaces and install parking meters.
- Identify appropriate locations for commercial loading zones, and paint the appropriate parking restrictions for trucks at the curbsides.
- Identify appropriate locations to site off-street parking facilities to address the high parking demand on Harvard Avenue.
- Paint bus reservations at the bus stops.
- Enforce parking restrictions.

Harvard Street at Beacon Street (Coolidge Corner), Brookline

- Remove two spaces of legal parking on the southbound side of Harvard Street.

Tremont Street and Huntington Avenue, Roxbury

- Stripe the parking lanes with parking spaces and install meters. This should discourage drivers from attempting to fit too many cars in a given segment. Set a lower limit to the number of cars permitted to park on the street.
- Forbid on-street parking at locations where the lane geometry is too narrow to safely accommodate parking, such as the curbside fronting the Calumet Market.
- Consolidate some bus stops on both sides of Tremont Street between Roxbury Crossing and Huntington Avenue in order to free up curb space for on-street parking and reduce the conflict between bus and traffic maneuvers.
- Mark the pavement at bus stops with large lettering and bus-length bays to clearly distinguish the bus stops from parking spaces.
- Reserve a portion of the curb on both sides of Tremont Street for commercial loading zones. These should be staggered, instead of being directly across from one another. Set time limits on commercial parking activity.
- Search for an appropriate location to site an off-street parking facility.

New Dudley Street between Tremont Street and Shawmut Avenue, Roxbury

- Stripe the eastbound side of New Dudley Street to clearly differentiate the parking area from the right-turn-only lane.
- Enforce the parking restrictions on New Dudley Street.
- Provide for parking lanes in each direction when repairing and/or restriping the street.
- Reduce the number of bus stops to two in each direction in order to reduce the conflicting demand for curbside space among buses and cars.
- Mark bus loading zones on the pavement with painted bus bays for the full length of the bus reservation.

Dudley Street at Shawmut Avenue and Washington Street, Roxbury

- Enforce the "No Stopping" and other parking restrictions in this area.

- Remove the inconsistent parking signage.

Warren and Dudley Street

- Install parking meters and stripe the parking spaces on Warren Street approaching Dudley Street and north of the intersection.
- Install parking meters on Dudley Street westbound and west of the intersection.
- Eliminate the parking spaces in front of A Nubian Notion to facilitate traffic flow.

Dudley Square

- Search for an appropriate location to site an off-street parking facility. Given the prevalence of on-street parking and the disregard for parking restrictions indicates a demand for a parking facility in the area.

IMPLEMENTATION

Implementation of many of these recommendations depends on community approval. For example, parking elimination, bus stop relocation, and concurrent pedestrian signal phases may be controversial strategies and may possibly not be practical in certain areas. Public outreach efforts should be undertaken before implementation of these types of improvements.

In the case of improvements to the bus service, the responsibility for implementation belongs to the MBTA, with support from the local governments. The implementation of adaptive traffic signal controls would require careful three-way coordination between: the local governments and MassHighway, who own and control the traffic signals, and the MBTA, operator of the buses. Bus stop signing and relocation and some pavement striping also require careful communication between the municipalities and the transit authority. The responsibility for implementing arterial improvements (parking and intersection recommendations), lies with either the City of Boston, the Town of Brookline, MassHighway, or the Metropolitan District Commission, depending on the location. (Appendix I provides notes from discussions with the implementing agencies that were made during the course of the study.)

Each of the various recommendations can be implemented according to plans determined by the implementing agencies. Except for the adaptive traffic signal controls, the implementation of one recommendation does not depend on the implementation of another. In other words, projects can proceed when the implementing agencies are ready.

Summary of Issues and Recommendations

The six-mile-long Bus Route 66, which provides crosstown service between Dudley Square and Harvard Square, is among the busiest routes in the MBTA bus system, with an average weekday ridership of between 11,000 and 12,000 passengers. The bus travels along a densely developed urban corridor through numerous intersections, most of them signalized. Low speeds between intersections and delays at signalized intersections are typical during the peak hours of travel, morning, midday, and evening. As a result, this bus route has schedule adherence deficiencies, which in turn appear to cause a number of trips violating the MBTA's passenger loading standard. The purpose of this study has been to identify congestion problems along the corridor and develop traffic- and bus-operations strategies to mitigate these problems. If implemented, this study's recommendations, which are summarized below, would collectively have a positive impact both on the operation of Bus Route 66 and on general mobility and safety along the corridor.

First, the bus operations were examined. The study found that even though the buses normally depart on time, they are often late arriving at destinations. For instance, fifty percent of the outbound trips in the morning peak period exceed the loading standard, carrying heavy passenger loads for most of the route. Individual bus trips that ran very late were found to be quite crowded, as they tend to pick up passengers who would otherwise have taken the following bus. This study's recommendations related to bus operations may be summarized as follows:

- Adjust the scheduled running times, to better reflect actual travel times.
- Increase the level of service for weekday middays and Saturdays.
- Relocate, consolidate, or eliminate bus stops.

Once other recommendations have been implemented—and have resulted in changes to mobility in the corridor—another look at scheduled and actual running times will be necessary.

In addition, the study recommends investigating the use of adaptive traffic signal controls. The use of traffic signal priority for transit has yielded beneficial results in bus operations in other metropolitan areas. This corridor, if deemed a viable candidate, may also benefit from the use of ITS technology. The tests already planned by the MBTA of AVL deployment on selected bus routes will provide invaluable insight into the practicality of incorporating this promising technology in its transit operations.

The study found that traffic flow along the corridor is impeded by parking conditions—the greatest single factor adversely affecting the bus service. Hence, the study makes several general recommendations on parking management:

- Apply more strict enforcement of existing parking regulations, including the no-parking restriction at bus stops.
- Clearly mark loading and unloading spaces for commercial vehicles.
- Improve definition of legal parking with pavement striping, curb extensions, parking meters, and parking-restriction signs. Consider limiting on-street parking to fewer vehicles.
- Remove parking areas at intersection approaches to facilitate turning movements.

- Contract parking studies in Roxbury to identify needs and recommend, if appropriate, off-street parking. The parking demand in Brighton should also be studied.

Location-specific recommendations related to parking have been detailed in this report.

Another element of the corridor that was explored is the effect of signalized intersection delay on the bus service. The operations of 31 signalized intersections were analyzed using data collected from each of three time periods: the morning, midday, and evening peak hours. Many of these intersections demonstrate failing levels of service for at least one approach in at least one of the periods. Delays and queues are worst during the evening peak hour. This study's recommendations for intersection improvements fall in the following categories:

- Shorter cycle lengths
- Modified signal timings and/or phases
- Elimination of exclusive pedestrian phases
- Signal coordination
- Lane reallocation to traffic movements
- Parking elimination near intersections
- Bus stop relocation

The application of the appropriate types of intersection/signal improvements has been detailed in the report. In general, the recommended strategies, if implemented, would not be expected to dramatically improve the operation of the intersections, but rather should improve their levels of service to marginally acceptable ones.

Appendices

APPENDIX A: ROUTE 66 ANALYSIS AND PROPOSED CHANGES (TECHNICAL MEMORANDUM)

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Appendix A:

Route 66 Analysis and Proposed Changes (Technical Memorandum)

MEMORANDUM

TO: David Carney, MBTA

September 24, 1998

FROM: Stephen Falbel

RE: Route 66 Analysis and Proposed Changes

This memorandum describes an analysis of schedule adherence and loading performed on Route 66. This work was done in conjunction with the Route 66 traffic study being conducted by the CTPS Traffic Analysis and Design group.

SUMMARY OF RECOMMENDATIONS

- Several adjustments to the scheduled run times are recommended below in order to improve schedule adherence.
- The only time period for which a change in level of service is recommended is the midday period for both weekdays and Saturdays. Because of the current difficulty in meeting the schedule and overall crowded conditions, it is recommended that an additional vehicle be brought into service and that headways be reduced from 15 minutes to 14 minutes, as the cycle time is increased from 90 minutes to 98 minutes.

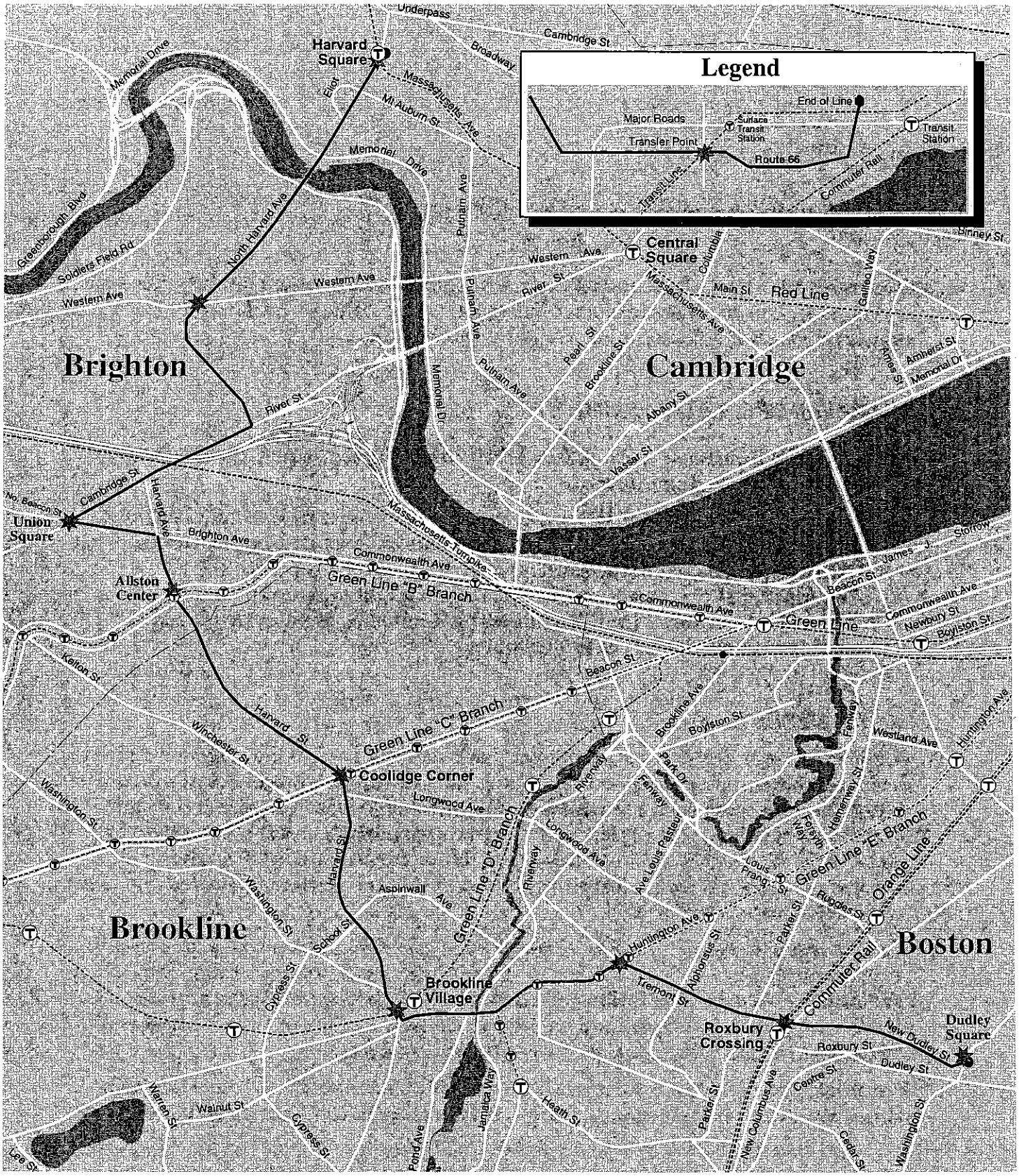
ROUTE DESCRIPTION

Route 66 is one of the MBTA's primary crosstown services, connecting several densely-developed neighborhoods three to four miles from downtown Boston. In the inbound direction it runs from Harvard Square through Allston to Union Square and then into Brookline where it runs along Harvard Street, crossing the B, C and D branches of the Green Line. It then reenters Boston, serving Huntington Avenue and Brigham Circle before turning onto Tremont Street which leads it through Roxbury Crossing and finally to Dudley Square (see Figure 1).

There is only one variation of Route 66 currently operating, numbered 66.6. It operates seven days per week from before 5:00 A.M. to after 1:00 A.M. Monday through Saturday, and from 6:00 A.M. to after 1:00 A.M. on Sunday. Peak period headways are nine or ten minutes, with midday and Saturday headways of fifteen minutes, evening headways of twenty-five minutes and Sunday headways of forty minutes.

The route carries heavy loads for almost its entire alignment. For inbound weekday trips, more than 1,600 passengers board at the three stops in Cambridge, and the load

Figure 1
Study Area for MBTA Bus Route 66
Arterial Improvement Study



does not drop to below 1,600 until New Dudley Street at Columbus Ave, just five stops from Dudley Square. Loads in the outbound direction are similar. Boarding and alighting activity occurs all along the route, but the greatest concentrations are at the termini and at the locations where the route crosses the Orange Line and the four branches of the Green Line.

Over half of the riders on Route 66 use it for trips between home and work and another 16% use it for trips between home and school. Other trip purposes account for between 2 and 6% of the riders. Most riders are dependent on transit for all of their travel: 77% had no automobile available for their trip and 51% of riders come from households that own no vehicles. More than 77% of riders use the route at least five days per week. The percentage of elderly riders is relatively low on Route 66 at only 6% (9% of riders claimed that they paid senior citizen/disabled reduced fares). Women make up 68% of the riders on Route 66, which is nearly equal to the systemwide average.

SERVICE STANDARDS COMPLIANCE

- The span of service for Route 66 complies with standards for all days.
- Service frequency for Route 66 also complies with standards for all days.
- The weekday net cost per passenger for Route 66 is $0.59, which is well below the systemwide average. The Saturday net cost is $0.79, which is also below the average. The Sunday net cost per passenger is $0.61 which is also below the average. These net costs mean that Route 66 is one of the best performing routes in the system in financial terms.
- Schedule adherence did not comply with standards for any day of the week as discussed below.
- Route 66 service as a whole complied with loading standards, but there were 38 individual weekday trips and six Saturday trips which violated standards, as discussed below. Indeed, if the peak-30 minutes by time period is examined, rather than the time period as a whole, there are several time periods in which the route does not comply with loading standards.

OVERVIEW OF RIDERSHIP

The most recent ridecheck information for Route 66 was collected in Spring 1997. Table 1 below shows total ridership by time period and then breaks down the figure into average boardings per trip and the average maximum load by time period and by peak-30 minute interval. Overall ridership on the route is very high, at more than 11,000 weekday passengers. This figure ranks Route 66 among the top five routes in the MBTA system. Boardings and loads are high in all time periods for all days of the week.

Certain figures in Table 1 stand out, specifically the peak-30 minute loads for the weekday evening time period and for Sunday in the inbound direction, and the

weekday A.M. peak time period in the outbound direction. The very high loads for the two inbound time periods[1] reflect two individual trips (one in each time period) which experienced extreme crowding. These trips also ran very late, partly because they were so crowded, with the result that they ended up picking up passengers who would normally have taken the following bus. Because not all trips were checked on the same day, it is impossible to tell from the current data whether the trips following these crowded trips had abnormally light ridership. The crowding on A.M. peak outbound trips reflects a more sustained period of crowding. See the section on loading below for a full discussion.

Table 1
Route 66 Ridership, Average Boardings and Maximum Load by Time Period (1997)

Inbound	Total Boardings	Boardings/ Trip	Time Period Avg. Max. Load	Peak 30 min. Avg. Max. Load
Early A.M.	196	32.7	19.3	23.0
A.M. Peak	751	68.3	41.4	48.8
Midday	2,214	63.3	31.0	43.0
P.M. Peak	869	72.4	33.6	38.2
Evening	1,502	53.6	32.9	53.3
Weekday	5,532	60.1	32.4	46.0
Saturday	2,808	40.1	21.2	42.5
Sunday	1,279	42.6	23.4	59.0
Outbound				
Early A.M.	509	50.9	27.4	36.2
A.M. Peak	1,175	97.9	48.0	58.5
Midday	2,482	68.9	33.8	42.5
P.M. Peak	818	68.2	33.2	40.8
Evening	635	27.6	15.3	35.0
Weekday	5,619	60.4	30.3	43.4
Saturday	2,718	38.8	20.5	47.0
Sunday	1,452	45.4	23.5	36.0

SCHEDULE ADHERENCE

WEEKDAY SCHEDULE ADHERENCE

There are five data points for Route 66 weekday schedule adherence information over the last two and a half years. The route has been ridechecked twice, in Rounds I (Spring

[1]Because Saturdays and Sundays are not divided into time periods, each day as a whole is considered to be one time period.

1996) and II (Winter 1997) of the Comprehensive Ridecheck Program, yielding full-day coverage, albeit a composite day with different trips checked on different days. In addition, timechecks were conducted on three days in April 1998 between 7:00 A.M. and 9:00 A.M., 11:30 A.M. and 1:30 P.M., and 4:00 P.M. and 6:00 P.M. Departure and arrival time data were collected at the two endpoints (Harvard and Dudley) and three intermediate points (Brookline Village, Coolidge Corner and Commonwealth Ave). Because of the different amounts of data available for the various parts of the day, each time period will be treated separately. Time periods for which only the ridecheck data are available will be analyzed first, followed by the three time periods listed above. All of the recommended run and cycle times are summarized in Tables 2 and 6 on pages 7 and 12.

Note that since the time the run time data were collected, the routing of Route 66 in the Harvard Square area has changed. Rather than following JFK Street to Massachusetts Avenue through the square, outbound buses now enter the bus tunnel via Bennett Alley. The inbound routing is unchanged. There are no data available to determine the effect of this change, but it can be assumed that outbound run times have decreased by a minute or two.

Early A.M.

According to standard time period definitions, six inbound and ten outbound trips belong to the Early A.M. period. Data from the two sets of ridechecks differ in their evaluation of on-time performance. These differences are partly due to seasonal variation—trips often take longer to run in the winter because of weather conditions—and normal daily variation.

All departures were on time in both sets of data, but relatively few trips arrived on time. In the inbound direction (Harvard to Dudley) scheduled run time appears adequate until the 6:30 A.M. departure, at which time observed run time increases. Assuming changes are made to the A.M. peak run times as discussed below, the 6:30 and 6:40 trips would receive additional run time as transitional trips. Thus, no changes to the schedule are recommended.

In the outbound direction, scheduled run time is inadequate for all trips starting later than 6:00 A.M. It is recommended that four minutes be added for trips between 6:10 A.M. and 6:50 A.M. to raise the scheduled run time from 26 to 30 minutes. Such a change would require alterations to the schedule, as relatively tight cycles are interwoven with pullouts between 5:00 A.M. and 7:00 A.M. For example, the 6:10 A.M. outbound bus is currently scheduled to begin its inbound trip at 6:40 A.M. A 30-minute outbound trip would not allow it to meet that departure time reliably.

Early Midday

In the period between 8:20 A.M. and 11:15 A.M., only two departures were recorded as being more than five minutes late in the two data sets, and they both occurred in the 1996 ridechecks. For inbound trips, the average run time was only slightly greater than the 39 minutes currently scheduled, but there was a great deal of variation. In the 1996 checks, run times varied between 29 and 54 minutes, and in the 1997 checks, run times

varied between 30 and 51 minutes. There was no particular pattern to the variation and no consistency from year to year. Thus, no recommendations can be made.

In the outbound direction there was somewhat less variation. Most observed run times were longer than the scheduled times, reflected in a greater difference between the average observed time and the scheduled time (six minutes in 1996 and three minutes in 1997). Based on these observations, the scheduled run time for the period beginning at 9:00 A.M. should be increased from 36 minutes to 39 minutes.

Late Midday

In the period between 1:30 P.M. and 4:00 P.M., two outbound departures in the 1997 ridechecks were recorded as being more than five minutes late, but all other departures in the two data sets were on time. The average run time for inbound trips was 47 minutes in both data sets, six minutes more than the scheduled run time. In both years, however, there was quite a bit of variation in the observed run time, with times ranging from 37 minutes to 62 minutes. Enough trips took more than 45 minutes, though, to warrant extending the scheduled run time by at least four minutes.

Run time data for outbound trips are more inconsistent. In 1996 ridechecks, the average run time was close to the scheduled time (42 minutes) but there was much variation, with times ranging from 30 minutes to 57 minutes. In the 1997 ridechecks, there was less variation, but the average time was longer (45 minutes). Because of the inconsistency and because most of the observed times were not significantly longer than the scheduled time, the current 42-minute run time should be retained.

Evening

The evening time period extends from 6:00 P.M. to 9:00 P.M. There were five late departures in the data sets, four of which occurred in the 1997 checks, two inbound and two outbound. Observed run times were generally longer than the scheduled times, especially in the 1997 data. In the inbound direction, the 1997 average run time was 43 minutes, 7 minutes longer than the 36-minute scheduled time; there was only one trip that took less than 36 minutes, and four trips took at least 50 minutes. Although there was much variation in the observed run times and several trips in the 1996 ridechecks ran more quickly, it would be beneficial to extend the scheduled run time to 40 minutes.

Both sets of outbound ridechecks suggest an extension of scheduled run time from 35 minutes to 39 minutes. The 1996 data exhibit relatively consistent run times of 39 or 40 minutes while the 1997 data show more variation.

Night

Trips from 9:00 P.M. to the end of service after 1:00 A.M. have an inbound scheduled run time of 28 minutes and an outbound time of 26 minutes. Most trips departed on time, except for one bus in the 1997 checks which ran significantly behind schedule for its entire assignment. Inbound trips ran faster in 1997 than in 1996. Indeed, 1996 data would suggest splitting this run time period at 11:00 P.M. and having a 34-minute run time before 11:00 P.M. and a 31-minute run time from then to the end of service. 1997

data do not support this revision, however. Lacking further data, no changes are recommended to the inbound schedule.

Outbound run times in 1997 were remarkably close to the schedule, although the same can not be said for 1996 observations. Among the latter there was much variation and no clear pattern as there had been for the inbound direction. Because the 1997 times match the schedule and the 1996 data are inconclusive, no changes to outbound times are recommended. The recommended changes to the run time periods discussed so far are summarized in Table 2 below.

Table 2
Route 66 Non-Peak Weekday Schedule Statistics: Current and Proposed

	BOS - 6:59 A.M.	9:00 A.M. - 1:59 P.M.	2:00 P.M. - 3:59 P.M.	6:00 P.M. - 8:59 P.M.	9:00 P.M. - EOS
Current Schedule Statistics					
Run Time					
Inbound	28	39	41	36	28
Outbound	26	36	42	35	26
Layover Time					
Inbound	2/7	6	13/14	14	12
Outbound	4	9	17/18	10	9
Cycle Time	65	90	114	100-90	75
Headway	30-15	15	9/10	10-15	25
Vehicle Requirement	4-7	6	12	9-6	3
Layover/Run Time	11-20%	20%	37%	34%	39%

	BOS - 5:59 A.M.	6:00 A.M. - 6:59 A.M.	9:00 A.M. - 11:29 A.M.	1:30 P.M. - 3:59 P.M.	6:00 P.M. - 8:59 P.M.	9:00 P.M. - EOS
Proposed Schedule Statistics						
Run Time						
Inbound	28	28	39	**45**	**40**	28
Outbound	26	**30**	**39**	42	**39**	26
Layover Time						
Inbound	2/7	8	10	10	10	12
Outbound	4	9	10	17	11	9
Cycle Time	65	**75**	**98**	114	100-**96**	75
Headway	30-15	10	**14**	9/10	10-**16**	25
Vehicle Requirement	4	7-8	7	12	9-6	3
Layover/Run Time	11-20%	29%	26%	31%	27%	39%

Note: BOS = beginning of service, EOS = end of service
Changes in run time, cycle time, vehicle requirement and headway are shown in **bold**

Note that because of the adjustments to the run times, changes in cycle times and headways in the early midday and evening time periods are recommended.

Specifically, the cycle time from 9:00 A.M. to 11:29 A.M. is suggested to increase from 90 to 98 minutes and the headway to decrease from 15 minutes to 14. These changes would require one additional vehicle in service. High loads on buses during this time period provide additional justification for an increase in service (see Table 1), beyond the schedule adherence issue. The cycle time for the latter part of the evening time period, roughly 7:20 to 9:00 P.M., is also suggested to change, from 90 minutes to 96, with the headway increasing from 15 minutes to 16. There would be no increase in cost associated with this change. The effect of increasing the early morning outbound run time from 26 to 31 minutes is unclear because cycle times are in transition during this time period as more vehicles are brought into service.

A.M. Peak

According to the official definition, inbound trips arriving and outbound trips departing between 7:00 A.M. and 8:59 A.M. belong to the A.M. peak period. Data collection in April 1998 consisted of checkers at five locations recording the times buses arrived and departed. For the A.M. peak period, checkers collected data between 7:00 A.M. and 9:00 A.M. Because roughly three inbound trips arriving during the A.M. peak departed from Harvard Square before 7:00 A.M., and three outbound trips departing during the A.M. peak arrived at Dudley after 9:00, complete run time information is not available for all A.M. peak trips.

Run time information for A.M. peak inbound and outbound trips is shown below in Table 3. Observations from rounds 1 and 2 of the Comprehensive Ridecheck Program are shown along with the three observations from April 1998. Note that the scheduled inbound run time is 37 minutes and the scheduled outbound run time is 35 minutes. Note also that the "n/a" for the 8:10 A.M. trips on April 9 and April 14 means that those trips took longer than 50 minutes to complete, otherwise the arrivals would have been recorded by the checkers prior to completing their assignments at 9:00 A.M.

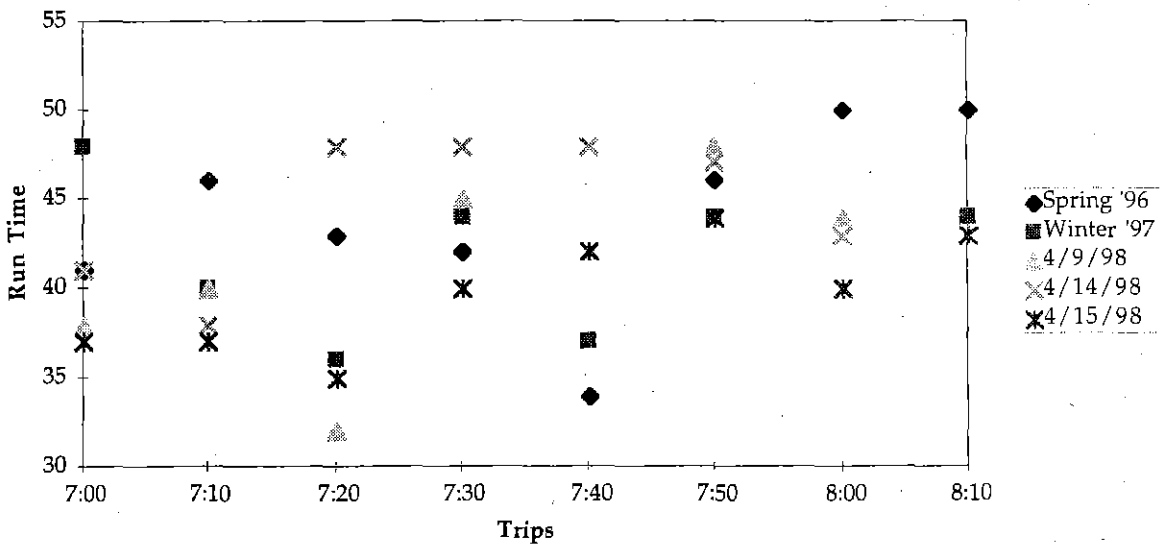
It is clear from Table 3 that there is a great deal of variation in run times from trip to trip within each day and across different days. Figure 2 below further illustrates this variation, graphing the A.M. peak inbound run times. A graph of the outbound run times would show even more variation, as indicated by the numbers in Table 3, particularly the standard deviation (a statistical measure of variation) which is higher for outbound trips than for inbound trips.

In spite of the variation in A.M. peak run times, 42 minutes represents a reasonable average run time for both the outbound and inbound directions. It is certainly a more reasonable average than the current scheduled times of 37 inbound and 35 minutes outbound. Resetting the schedule to 42 minutes in each direction will not solve the schedule adherence problems of Route 66, because some trips will continue to run very early (up to 14 minutes) while other trips will run very late (up to 13 minutes). It is probably worthwhile as a first step, however.

Table 3
Route 66 Weekday A.M. Peak Run Times (Minutes)

Sch. Dep.	Spring 1996	Winter 1997	April 9, 1998	April 14, 1998	April 15, 1998	Average	St. Dev.
Inbound							
7:00	41	48	38	41	37	41.0	4.3
7:10	46	40	40	38	37	40.2	3.5
7:20	43	36	32	48	35	38.8	6.5
7:30	42	44	45	48	40	43.8	3.0
7:40	34	37	42	48	42	40.6	5.4
7:50	46	44	48	47	44	45.8	1.8
8:00	50	n/a	44	43	40	44.3	4.2
8:10	50	44	n/a	n/a	43	45.7	3.8
					All trips	42.3	4.6
Outbound							
7:00	36	39	34	28	37	34.8	4.2
7:10	36	n/a	34	38	31	34.8	3.0
7:20	48	42	48	49	39	45.2	4.4
7:30	55	46	42	38	43	44.8	6.4
7:40	45	n/a	51	47	42	46.3	3.8
7:50	35	38	45	42	47	41.4	4.9
8:00	50	n/a	39	50	53	48.2	5.4
8:10	52	45	n/a	n/a	45	46.4	4.2
					All trips	42.5	6.6

Figure 2
Weekday Inbound AM Peak Run Times for Route 66



Midday

The data collection effort in April 1998 covered five inbound trips and seven outbound trips during the midday period. In the inbound direction (Harvard to Dudley), the trip departing at 12:45 P.M. arrived at Dudley after 1:30 P.M. on all three days of data collection, at which point the checkers had left. This implies that the run time for the 12:45 trip is typically longer than 45 minutes. In the outbound direction, the trip departing at 12:45 arrived at Harvard before 1:30 on one day out of three, and on another day, the trip departing at 1:00 P.M. arrived at 1:34, early enough to be caught by the checker.

Run time observations for the midday period are shown below in Table 4. Note that the scheduled inbound run time is 39 minutes and the outbound time is 36 minutes.

Table 4
Route 66 Weekday Midday Run Times (Minutes)

Sch. Dep.	Spring 1996	Winter 1997	April 9, 1998	April 14, 1998	April 15, 1998	Average	St. Dev.
Inbound							
11:30	35	42	38	37	44	39.2	3.7
11:45	48	40	n/a	40	n/a	42.7	4.6
12:00	43	37	44	39	48	42.2	4.3
12:15	46	47	39	37	43	42.4	4.3
12:30	43	n/a	37	40	35	38.8	3.5
					All trips	41.0	4.1
Outbound							
11:30	37	39	42	34	45	39.4	4.3
11:45	44	44	37	37	38	40.0	3.7
12:00	42	40	39	38	42	40.2	1.8
12:15	35	43	35	40	40	38.6	3.5
12:30	43	48	36	46	36	41.8	5.6
12:45	55	33	n/a	n/a*	39	42.3	11.4
1:00	32	43	n/a	34	n/a	36.3	5.9
					All trips	39.8	4.9

*Note: This bus was passed by its follower (the 1:00 P.M. trip) between Coolidge Corner and Commonwealth Ave.

Among the observed inbound trips, only four are late according to service standards (more than five minutes late) and seven are early. Increasing the scheduled run time to the 41-minute average would decrease the number of late trips by only one, but would increase the number of early trips by five. Thus, it is not recommended to change the inbound scheduled run time.

For outbound trips there is a greater case for increasing the scheduled run time. Ten trips were late according to standards, and only five trips were early. Increasing the run time to 39 minutes would reduce the number of late trips by seven and increase the

number of early trips by seven, though five of these would be early by only 1 or 2 minutes. It is thus recommended to increase the outbound run time to 39 minutes.

P.M. Peak

Eight inbound and eight outbound trips departing between 4:00 P.M. and 5:10 P.M. were observed in the April 1998 data collection effort. These trips do not constitute the entire P.M. peak as defined in the service policy, but they do encompass the trips with the heaviest ridership. Run time observations for the P.M. peak are shown in Table 5. The inbound scheduled run time is 41 minutes and the outbound time is 42 minutes.

Table 5
Route 66 Weekday P.M. Peak Run Times (Minutes)

Sch. Dep.	Spring 1996	Winter 1997	April 9, 1998	April 14, 1998	April 15, 1998	Average	St. Dev.
Inbound							
4:05	49	40	47	37	38	42.2	5.4
4:15	50	51	49	53	52	51.0	1.6
4:24	55	42	46	46	45	46.8	4.9
4:34	31	50	44	51	48	44.8	8.2
4:43	49	47	48	47	46	47.4	1.1
4:53	57	45	42	47	55	49.2	6.5
5:00	50	48	48	46	49	48.2	1.5
5:10	57	54	n/a	48	n/a	53.0	4.6
					All trips	47.6	5.4
Outbound							
4:03	47	50	52	40	47	47.2	4.5
4:12	39	50	40	30	40	39.8	7.1
4:22	44	40	50	53	42	45.8	5.5
4:30	50	56	44	51	57	51.6	5.2
4:40	46	65	50	47	42	50.0	8.9
4:50	50	n/a	54	49	42	48.8	5.0
5:00	57	n/a	n/a	50	56	54.3	3.8
5:10	56	53	n/a	45	47	50.3	5.1
					All trips	48.1	6.8

It is clear that the scheduled run times are inadequate. Of the 38 inbound observations shown in the table, 34 of them have run times greater than the scheduled 41 minutes and 25 of them have run times greater than the allowed 46 minutes. Only 4 trips have run times shorter than 41 minutes. In the outbound direction, 27 of 36 observations have trip times greater than the scheduled 42 minutes and 19 (still more than half) have trip times greater than the allowed 47 minutes. Only eight trips had trips times shorter than 42 minutes.

Even though many observed run times are longer than the schedule, there is still a great deal of variation, as demonstrated by the high standard deviations shown in Table 5. Inbound run times vary between 31 and 57 minutes, and outbound times vary between

30 and 65 minutes. The median inbound time is 48 minutes and the median outbound time is 49.5 minutes.

Table 6
Route 66 Peak and Midday Weekday Schedule Statistics: Current and Proposed

	7:00 A.M. - 8:59 A.M.	11:30 A.M. - 1:29 P.M.	4:00 P.M. - 5:59 P.M.
Current Schedule Statistics			
Run Time			
Inbound	37	39	41
Outbound	35	36	42
Layover Time			
Inbound	14	6	13-16
Outbound	13	9	18
Cycle Time	99	90	117
Headway	9	15-10	9/10
Vehicle Requirement	11	6-9	12
Layover/Run Time	38%	20%	39%
Proposed Schedule Statistics			
Run Time			
Inbound	**42**	39	**47**
Outbound	**42**	**39**	**48**
Layover Time			
Inbound	8	10	10
Outbound	7	10	12
Cycle Time	99	**98**	117
Headway	9	**14-10**	9/10
Vehicle Requirement	11	**7-10**	12
Layover/Run Time	18%	26%	23%

Note: Morning peak schedule statistics are the ones in effect in Fall 1998. At the time of data collection, 10-minute headways were operated with 10 vehicles on a 100-minute cycle.
Changes in run time, cycle time, vehicle requirement and headway are shown in **bold**

In view of these statistics, it is recommended that inbound run time be increased from 41 to 47 minutes and outbound be increased from 42 to 48 minutes. Table 6 summarizes the recommendations for the A.M. peak, midday and P.M. peak periods and shows the implications for cycle times and headways.

Changes in A.M. and P.M. peak run times do not necessitate changes in cycle times because the current layovers are generous. Layover time can be converted to run time (which is essentially what is happening on the street) such that the remaining layover is still approximately 20% of the run time. Note that the A.M. peak cycle time is possibly

too short. Further monitoring is necessary to determine if there are consistent late departures as a result of inadequate layover time.

In the midday period, it is recommended to extend the cycle time to 98 minutes and put an extra vehicle into service. The recommendations in Table 2 already included this change for the time period immediately preceding this midday period. Loads during this time period also justify an increase in service.

WEEKDAY BUNCHING ANALYSIS

Collection of timecheck data allows for an assessment of the degree to which bunching occurs along the route. Ideally, buses would maintain regular headways for the whole length of the route in order to minimize average wait time. Because of the variability of traffic, uneven loads on buses, uneven arrival of passengers at stops, the driving habits of the operators and other factors, such regular headways are rarely seen.

Table 7 shows the observed headways between buses at the five data collection locations for A.M. peak inbound (Harvard to Dudley) trips on April 9, 1998.[2] This information is then graphed in Figure 3.

In the table and on the graph, one can see that the headways are reasonably regular at the start of the inbound trips (at Harvard Square), hovering around the scheduled 10-minute headway. As one moves to the right the headways become much less regular. In fact, by the time buses reach Coolidge Corner, the 10-minute headway has all but disappeared.

Although it is impossible to explain the irregularities merely from the numbers in Table 7, it would appear that operator behavior plays a significant role. Specifically, early departures, even ones only one or two minutes early, can lead to bunching later in the route. Look for example at the 7:20 and 8:00 departures, both of which departed two minutes early. By the time the 7:20 bus reached Coolidge Corner, it was only one minute behind the previous bus, and it ended up reaching Dudley *before* the previous bus. The 8:00 bus did not actually catch up to the previous bus, but by Brookline Village it was only three minutes behind. In both of these cases, there was a large gap in service after these buses (24 and 20 minutes, respectively, at Brookline Village) because they were running so far ahead of schedule.

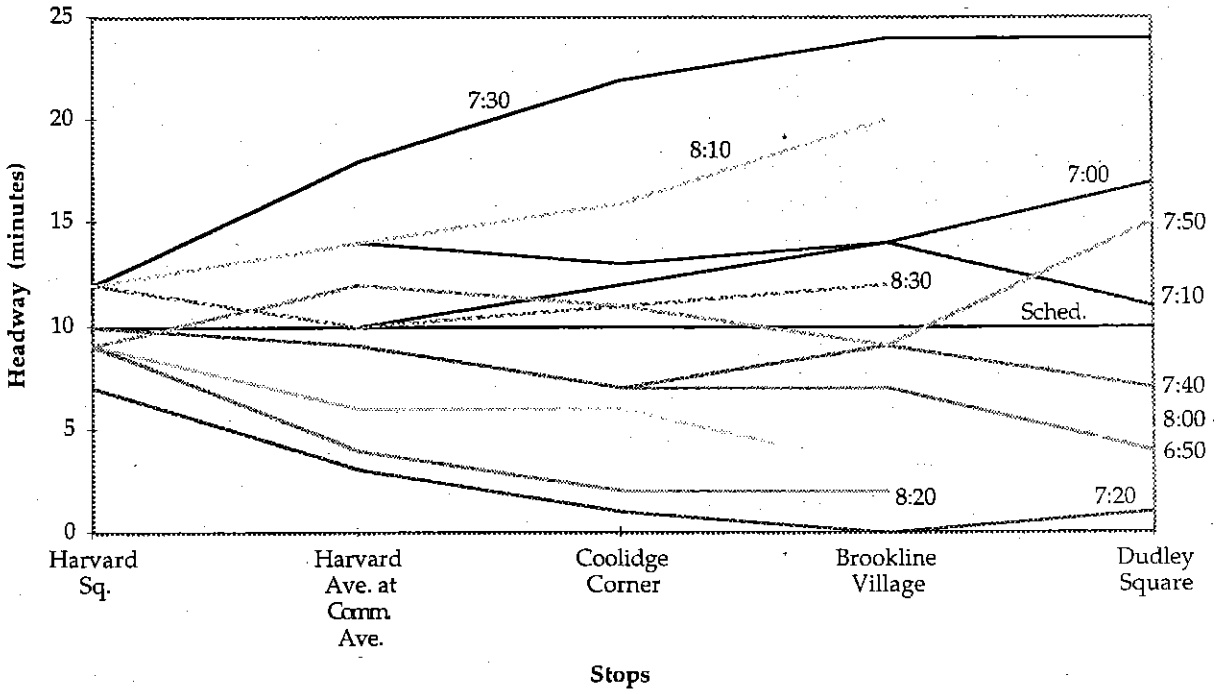
It may have been that the drivers of these two trips not only left early but also drove the route quickly. Even if they did not drive faster than average, though, the fact that they left early would mean that they would pick up fewer passengers (since there would not be a full headway of wait time for passengers to accumulate), and thus would get ahead of schedule due to reduced dwell times and fewer stops.

[2]Current scheduled departure times are different because of the increase in service effective Fall 1998.

Table 7
Route 66 A.M. Peak Inbound Headways (minutes from previous bus)

Scheduled Departure	Actual Departure	Vehicle No.	Harvard Sq.	Harvard Ave./ Comm. Ave.	Coolidge Corner	Brookline Village	Dudley Square	Actual Arrival
6:40	?	8634					15	7:18
6:50	?	0296			7	7	4	7:22
7:00	7:01	0318		14	13	14	17	7:39
7:10	7:11	8614	10	10	12	14	11	7:51
7:20	7:18	0117	7	3	1	0	1	7:50
7:30	7:30	0124	12	18	22	24	24	8:15
7:40	7:40	0094	10	9	7	9	7	8:22
7:50	7:49	0121	9	12	11	9	15	8:37
8:00	7:58	0306	9	6	6	3	5	8:42
8:10	8:10	0106	12	14	16	20		?
8:20	8:19	8634	9	4	2	2		?
8:30	8:31	0296	12	10	11	12		?

Figure 3
Headways for Route 66 AM Peak Inbound



The pattern shown above in Figure 3 is typical of both the A.M. and P.M. peak periods. In both the inbound and outbound directions, on all three days of data collection, headways at the start of the route were generally close to the scheduled headway but became highly variable in the middle and at the end of the route. Large gaps in service, preceded and followed by two or three buses arriving within minutes of each other, were observed in virtually all timechecks.

Midday service did not exhibit bunching to the same degree as peak period service. Partly as a result of longer headways (15 minutes between 11:30 A.M. and 1:00 P.M. as opposed to 9 or 10 minutes during peak periods) and slightly less severe traffic congestion, buses were better able to maintain even headways. Only three buses were observed to be less than five minutes behind another bus in three days of observations (a total of 50 to 60 buses observed).

The only way to combat bunching on a frequent bus route is to assign specific mid-route timepoints for each trip and then ensure that the drivers hold to those times. For a bus running early, the driver would have to wait for a few minutes before proceeding. The passengers on board may object to such a practice, but if they perceive more regular service overall, they would likely accept it.

SATURDAY SCHEDULE ADHERENCE

According to Winter 1997 ridechecks, scheduled run times for Saturday trips are too short in the afternoon and evening. Most midday and afternoon trips were recorded as arriving late, and six trips departed late, indicating that the midday cycle time is inadequate. Ridecheck data from 1996 confirm these findings. There is a significant amount of variation in the observed run times, but generally to a lesser degree than was observed with weekday run times.

Run times are currently divided into five time periods as shown in Table 8. Based on the ridecheck data, these time periods ought to be adjusted better to reflect changes in actual travel times.

The most significant change proposed in Table 8 is to increase the midday and afternoon cycle to 98 minutes and cut the headway to 14 minutes by bringing another vehicle into service. Reliable operations could also be achieved by extending the cycle to 96 minutes and stretching headways to 16 minutes. Many trips in this time period operate near the policy standard of 100% of seated load, providing some justification for an increase in service, or at least arguing against a cut in service.

Table 8
Route 66 Saturday Schedule Statistics: Current and Proposed

	BOS - 6:59 A.M.	7:00 A.M. - 8:59 A.M.	9:00 A.M. - 5:59 P.M.	6:00 P.M. - 8:59 P.M.	9:00 P.M. - EOS
Current Schedule Statistics					
Run Time					
Inbound	27	34	37	35	27
Outbound	25	32	36	31	25
Layover Time					
Inbound	3	11	8	10	13
Outbound	5	13	9	9	10
Cycle Time	60	90	90	85-75	75
Headway	30-15	15	15	15-25	25
Vehicle Requirement	2-4	6	6	5-3	3
Layover/Run Time	15%	37%	23%	29%	44%

	BOS - 8:29 A.M.	8:30 A.M. - 11:29 A.M.	11:30 A.M. - 6:59 P.M.	7:00 P.M. - EOS
Proposed Schedule Statistics				
Run Time				
Inbound	27	**33**	**42**	**34**
Outbound	**27**	**36**	**38**	**29**
Layover Time				
Inbound	4-10	10	10	7
Outbound	3-11	11	8	5
Cycle Time	60-75	90	**98**	75
Headway	30-15	15	**14**	25
Vehicle Requirement	2-3	6	**7**	3
Layover/Run Time	15-39%	30%	22%	19%

Note: BOS = beginning of service, EOS = end of service
Changes in run time, cycle time, vehicle requirement and headway are shown in **bold**

SUNDAY SCHEDULE ADHERENCE

The two sets of ridecheck data present differing results on Sunday schedule adherence. The 1996 data, collected primarily in May, exhibit run times far in excess of the scheduled times; furthermore, 13 of 62 trips departed late, indicating inadequate cycle times. The period from 12:00 P.M. to 8:00 P.M. encompassed most of the late trips, during which time the average inbound run time was 7 to 10 minutes longer than the 34 to 37 minutes scheduled, and the average outbound run time was 9 to 10 minutes longer than the 32 to 33 minutes scheduled.

Run time data collected in January, February and March 1997 tell a different story. Only three trips departed late, one of which was the last trip of the service day. Average run times in the midday period were significantly shorter, with the outbound time equal to the scheduled run time.

The results from the two rounds of ridechecks are confounding, especially since one would expect winter run times to be longer than spring run times. Rather than increase run times to match the 1996 results, which would entail an increase in cycle times and thus either an increase in headways or an increase in vehicle requirements, it is recommended to adjust run times to match the 1997 results and then monitor the situation further to determine if the 1997 run times were abnormally short. The recommended revisions are shown in Table 9.

Table 9
Route 66 Sunday Schedule Statistics: Current and Proposed

	BOS - 9:29 A.M.	9:30 A.M. - 1:29 P.M.	1:30 P.M. - 5:59 P.M.	6:00 P.M. - 8:59 P.M.	9:00 P.M. - EOS
Current Schedule Statistics					
Run Time					
Inbound	27	35	37	34	27
Outbound	25	32	33	32	25
Layover Time					
Inbound	13	15	13	6	13-8
Outbound	15	8	7	8	15-10
Cycle Time	80	80-90	90-80	80	80-70
Headway	40	40-30	30-40	40	40-35
Vehicle Requirement	2	2-3	3-2	2	2
Layover/Run Time	54%	34%	29%	21%	54-35%

	BOS - 8:59 A.M.	9:00 A.M. - 8:29 P.M.	8:30 P.M. - EOS
Proposed Schedule Statistics			
Run Time			
Inbound	**30**	**40**	**29**
Outbound	**30**	**33**	**30**
Layover Time			
Inbound	10	10	11
Outbound	10	7	10
Cycle Time	80	90	**80**
Headway	40	30	**40**
Vehicle Requirement	2	3	2
Layover/Run Time	33%	23%	36%

Note: BOS = beginning of service, EOS = end of service
Changes in run time, cycle time, vehicle requirement and headway are shown in **bold**

Note that the cycle time in the evening time period is recommended to be held at 80 minutes for the entire time period, rather than dropping to 70 minutes as it does now

after 9:00 P.M. This change affects only five round trips, and the improved reliability of the 80-minute cycle is worth the change in headways from 35 to 40 minutes.

LOADING

As mentioned above, Route 66 is one of the most heavily used routes in the MBTA bus system. Traveling in a crosstown orientation through several densely developed areas, the route carries significant loads for most of its alignment throughout the day in both directions. Figures 4 and 5 present the load profiles for weekday service.

At several times in the service day, Route 66 carries loads in excess of the policy standards. Table 1 above, based on 1997 data, shows that although the average maximum load over whole time periods do not violate standards, the load for the peak 30 minutes within each time period does violate the standard in eight cases: Inbound - early A.M., midday, evening, Saturday and Sunday; Outbound - A.M. peak, midday, and Saturday. Overcrowding was even more of a problem in 1996 than in 1997, as demonstrated below.

In addition to time period or peak 30-minute statistics, many individual trips violate load standards. Results from both sets of ridechecks are shown below in Table 10.

Table 10
Route 66 Trips Violating Load Standards by Time Period

	1996		1997	
Time Period	Inbound	Outbound	Inbound	Outbound
Early A.M.	2	2	1	2
A.M. Peak	1	7	1	2
Midday	14	8	9	7
P.M. Peak	2	0	0	1
Evening	7	1	7	1
Weekday	26	18	18	13
Saturday	8	6	3	3
Sunday	3	3	1	0

The period with the greatest number of violations is the midday period. The load standard for midday trips is 100% of seated capacity, or 40 passengers on the buses used on Route 66. In 1996 ridechecks, there was a cluster of inbound trips around 11:00 A.M. and several trips between 1:00 P.M. and 3:00 P.M. that violated the load standard. In 1997 ridechecks, the late morning trips were not overcrowded, but six inbound trips between 1:15 and 2:30 P.M. carried more than a seated load. The segment of the route carrying the greatest loads was between Commonwealth Avenue and Brookline Village. In the outbound direction, a smattering of trips earlier than 1:00 P.M. carried standees,

but there was no consistency or clustering of those trips; many other trips carried loads of between 30 and 40 passengers. Between 2:00 and 3:00 P.M. a few trips violated the standard in both 1996 and 1997 ridechecks.

The Evening time period had the next greatest number of violations, most of which occurred in the inbound direction. Ridechecks from 1996 show the crowding occurring between 5:20 P.M. (the first trip after the P.M. peak) and 7:10 P.M.. None of these trips carried more than 51 passengers at the peak load point.[3] In 1997, the violations are more spread out, extending from 5:30 P.M. to 10:15 P.M. Several of these violations were severe, with observed loads of 62 (5:30 trip), 79 (7:20 trip), 54 (9:00 trip) and 55 (10:15 trip). In both sets of ridechecks, outbound trips during the evening time period showed little crowding.

Outbound service in the A.M. peak period exhibited crowding in both data sets. In 1996, all trips but one between 7:10 A.M. and 8:20 A.M. violated loading standards, with an average of 66 passengers at the peak load point. In 1997, the crowding was not quite as severe, being restricted to 7:30 A.M. to 8:10 A.M. and an average of "only" 58. The greatest loads were observed in the segment between Union Square and Harvard Square.

The instances of crowding in the early A.M. period were not severe and in most cases occurred immediately prior to the beginning of the peak period. Load violations on Saturday exhibited no consistency between the two sets of ridecheck data. Most of the violations were not severe.

The schedule statistics proposed in the previous section recommended an increase in midday service, reducing headways from 15 minutes to 14 minutes. This additional service will help to alleviate the midday crowding described above. No increase in evening service is recommended here, as it is not clear at what time in the evening more service is needed. Trips with high loads alternated with trips with moderate loads. Note that most of the load violations occurred during the portion of the evening period when headways are 10 minutes; the increase in headways from 15 to 16 minutes recommended above affects only five round trips between 7:35 P.M. and 8:35 P.M., during which time crowding was not a problem.

The other time period for which an increase in service would be called for based on the 1996 and 1997 ridecheck data is the A.M. peak. At the time the data were collected, buses ran every 10 minutes in the A.M. peak, but as of Fall 1998, headways were reduced to 9 minutes by bringing an additional bus into service. At this writing, it is not known whether this increase in service will eliminate the load violations. No further increase in service is recommended until the effect of the recent service improvement can be determined.

In addition to consideration of crowding, the distribution of load over the length of the route is also worthy of examination. Figures 4 and 5 present the load profiles for

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[3]Note that if the peak directionality of the route were reversed, only three trips would violate the load standard, because trips prior to 6:00 p.m. would be subject to the 140% of seated capacity standard, rather than 100% of seated capacity.

weekday service as a whole graphically. As can be seen from the graphics, Route 66 is well used for its entire length. The overall peak load point in both directions occurs at Harvard Avenue near Fuller and Thorndike Streets in Brighton, located midway between the B and C branches of the Green Line. This location is also the peak load point for several individual time periods: Inbound - early A.M., A.M. peak and midday; Outbound - midday, P.M. peak and evening. In the other time periods, (that is, late in the day inbound and early in the day outbound) the peak load point is located near the intersection of North Harvard Street and Western Avenue in Allston. The peak load point on individual trips varies among several stops, but the general locations are quite consistent.

Appendix B:

Bus Operations—Analysis of Existing Conditions

Appendix B

Bus Operations—Analysis of Existing Conditions

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Summary of Contents/Background

An interim technical memorandum (provided in Appendix A) outlined recommendations to the scheduled running times for several time periods in order to improve the schedule adherence. That analysis of Bus Route 66 operations found that even though the buses depart on time, they are often late arriving at destinations. Furthermore, observations revealed that several of the bus trips tended to be crowded: exceeding the loading standard for the time period or carrying heavy passenger loads for most of the route alignment. Individual bus trips that ran behind schedule were found to be quite crowded, as they tended to pick up passengers who would otherwise have taken the following bus.

This appendix presents a set of additional technical notes on the Bus Route 66 operations that were not included in Appendix A. Schedule adherence information by time period was compared with the results of a recent travel time study (which used automobiles equipped with a Global Positioning System device). Ridership information—in conjunction with the delay estimates from the intersection capacity analysis—was used to assess the potential for consolidation of bus stops along the corridor, as well as calculating the extent of passenger-hours of delay. Passenger loading conditions on the bus are presented, as well, to highlight crowded conditions.

A. Schedule Adherence and Traffic Travel Time Delay

TABLES 1 AND 2

The travel time data collection that was conducted in the spring of 1998 (please refer to Appendix E) revealed a significant variation in automobile travel time. The observations also showed that as the day progresses, the average travel time increases. In comparison, observed bus trips demonstrated considerably wider variation in travel times (Table 1, on the following page) compared to vehicular traffic.

Table 2 shows the average observed running times and speeds by route segment from the sampled trips. Trip times from time points in the load profiles were averaged across the peak periods to obtain the average travel times. The table shows where and during which periods the delays occurred.

Comments and Observations

A great deal of variation is seen in run times from trip to trip within each day and across different days as demonstrated by the high standard deviations. Average run times differ significantly from the current scheduled run times by approximately 5 to 7 minutes in the morning peak period, 3 to 4 minutes in the midday period, and 6 to 7 minutes in the evening peak period.

Wide variability in traffic conditions necessitates extensive layover time. Once the drivers begin to fall behind schedule, a "domino effect" occurs as more passengers collect at stops and dwell times increase, further delaying the buses. Without the layover, the delays would be passed on to subsequent trips. Buses that follow late, crowded buses typically "run hot" (well ahead of schedule) and with light passenger loads.

TABLE 3

Table 3 shows the average bus running time and delay at signals by segment. (Bus route approach delays at particular traffic signals are listed in Section E).

Comments and Observations

Average signal delay should be viewed as a subset of bus running time. Hence, in order to improve bus running times, the segments with the highest average delay would be the logical targets for intersection level-of-service enhancements.

Table 1. Comparison of Observed Bus Trip Running Times

Inbound	Scheduled Departure	Spring 1996	Winter 1997	09-Apr-98	14-Apr-98	15-Apr-98	Average	Standard Deviation
		(all values in minutes)						
AM Peak	7:00	41	48	38	41	37	41.0	4.3
	7:10	46	40	40	38	37	40.0	3.5
	7:20	43	36	32	48	35	39.0	6.5
	7:30	42	44	45	48	40	44.0	3.0
	7:40	34	37	42	48	42	41.0	5.4
	7:50	46	44	48	47	44	46.0	1.8
	8:00	50	n/a	44	43	40	44.0	4.2
	8:10	50	44	n/a	n/a	43	46.0	3.8
	average	44	42	41	45	40	42.0	
Midday	11:30	35	42	38	37	44	39.0	3.7
	11:45	48	40	n/a	40	n/a	43.0	4.6
	12:00	43	37	44	39	48	42.0	4.3
	12:15	46	47	39	37	43	42.0	4.3
	12:30	43	n/a	37	40	35	39.0	3.5
	average	43	42	40	39	43	41.0	
PM Peak	4:05	49	40	47	37	38	42.2	5.4
	4:15	50	51	49	53	52	51.0	1.6
	4:24	55	42	46	46	45	46.8	4.9
	4:34	31	50	44	51	48	44.8	8.2
	4:43	49	47	48	47	46	47.4	1.1
	4:53	57	45	42	47	55	49.2	6.5
	5:00	50	48	48	46	49	48.2	1.5
	5:10	57	54	n/a	48	n/a	53.0	4.6
	average	50	47	46	47	48	48.0	
Outbound								
AM Peak	7:00	36	39	34	28	37	34.8	4.2
	7:10	36	n/a	34	38	31	34.8	3.0
	7:20	48	42	48	49	39	45.2	4.4
	7:30	55	46	42	38	43	44.8	6.4
	7:40	45	n/a	51	47	42	46.3	3.8
	7:50	35	38	45	42	47	41.4	4.9
	8:00	50	n/a	39	50	53	48.2	5.4
	8:10	52	45	n/a	n/a	45	46.4	4.2
	average	45	42	42	42	42	43.0	
Midday	11:30	37	39	42	34	45	39.4	4.3
	11:45	44	44	37	37	38	40.0	3.7
	12:00	42	40	39	38	42	40.2	1.8
	12:15	35	43	35	40	40	38.6	3.5
	12:30	43	48	36	46	36	41.8	5.6
	12:45	55	33	n/a	n/a*	39	42.3	11.4
	1:00	32	43	n/a	34	n/a	36.3	5.9
	average	41	41	38	38	40	40.0	
PM Peak	4:03	47	50	52	40	47	47.2	4.5
	4:12	39	50	40	30	40	39.8	7.1
	4:22	44	40	50	53	42	45.8	5.5
	4:30	50	56	44	51	57	51.6	5.2
	4:40	46	65	50	47	42	50.0	8.9
	4:50	50	n/a	54	49	42	48.8	5.0
	5:00	57	n/a	n/a	50	56	54.3	3.8
	5:10	56	53	n/a	45	47	50.3	5.1
	average	49	52	48	46	47	48.0	

* This bus was passed by the following bus (1 p.m.) between Coolidge Corner and Commonwealth Ave.

Notes:
Observations from rounds 1 and 2 of the Comprehensive Ridecheck Program are shown, along with the three observations from a point check of the route taken in the month of April 1998. Note that trips listed as "n/a" took longer than 50 minutes to complete. Otherwise, the checkers would have recorded the arrivals prior to completing their assignments at 9:00 a.m.

Table 2. Average Observed Bus Running Time and Speed by Route Segment and Time of Day

Inbound		A.M. Peak		Midday Peak		P.M. Peak	
Segment	**Length (miles)**	**Travel Time (min)**	**Speed (miles/ hour)**	**Travel Time (min)**	**Speed (miles/ hour)**	**Travel Time (min)**	**Speed (miles/ hour)**
Harvard Square to Western Ave	0.9	7.5	7	6.2	9	7.7	7
Western Ave to Union Square	1.1	5.7	12	8.0	8	8.2	8
Union Square to Coolidge Corner	1.3	8.2	10	11.2	7	12.2	6
Coolidge Corner to Brookline Village	0.8	7.0	7	5.6	9	7.0	7
Brookline Village to Brigham Circle	0.7	5.3	8	6.6	6	5.4	8
Brigham Circle to Roxbury Crossing	0.6	3.8	9	3.4	11	4.6	8
Roxbury Crossing to Dudley Station	0.6	3.8	9	5.2	7	3.7	10
Total	6.1	41.3	9	46.2	8	48.7	8

Outbound		A.M. Peak		Midday Peak		P.M. Peak	
Segment	**Length (miles)**	**Travel Time (min)**	**Speed (miles/ hour)**	**Travel Time (min)**	**Speed (miles/ hour)**	**Travel Time (min)**	**Speed (miles/ hour)**
Dudley Station to Roxbury Crossing	0.6	4.0	9	4.6	8	4.8	8
Roxbury Crossing to Brigham Circle	0.6	3.9	9	4.0	9	5.0	7
Brigham Circle to Brookline Village	0.7	5.0	8	4.8	9	6.2	7
Brookline Village to Coolidge Corner	0.8	6.9	7	6.4	8	6.8	7
Coolidge Corner to Union Square	1.3	8.7	9	10.2	8	10.8	7
Union Square to Western Ave	1.1	7.2	9	5.4	12	5.7	12
Western Ave to Harvard Square	0.9	6.9	8	6.4	8	10.2	5
Total	6.1	42.4	9	41.8	9	49.5	7

Table 3. Average Bus Running Time and Average Intersection Delay

Segment	A.M. Peak Pd.		Midday Period		P.M. Peak Pd.	
	Run Time	Avg. Delay[1]	Run Time	Avg. Delay[1]	Run Time	Avg. Delay[1]
Inbound						
Harvard Square to Western Ave	7.5	2.6	6.2	3.1	7.7	3.9
Western Ave to Union Square	5.7	2.2	8.0	1.2	8.2	2.9
Union Square to Coolidge Corner	8.2	1.7	11.2	1.6	12.2	3.6
Coolidge Corner to Brookline Village	7.0	1.4	5.6	2.4	7.0	3.5
Brookline Village to Brigham Circle	5.3	1.6	6.6	0.8	5.4	2.7
Brigham Circle to Roxbury Crossing	3.8	1.2	3.4	0.9	4.6	2.5
Roxbury Crossing to Dudley Station	3.8	1.3	5.2	1.0	3.7	1.2
Total	41.3	12.0	46.2	11.0	48.7	20.3
Outbound						
Dudley Station to Roxbury Crossing	4.0	0.8	4.6	0.7	4.8	1.0
Roxbury Crossing to Brigham Circle	3.9	1.3	4.0	1.2	5.0	3.2
Brigham Circle to Brookline Village	5.0	1.3	4.8	0.7	6.2	2.3
Brookline Village to Coolidge Corner	6.9	2.2	6.4	1.3	6.8	2.5
Coolidge Corner to Union Square	8.7	2.1	10.2	2.1	10.8	4.0
Union Square to Western Ave	7.2	1.7	5.4	1.0	5.7	3.3
Western Ave to Harvard Square	6.9	2.4	6.4	2.1	10.2	2.7
Total	42.4	11.8	41.8	9.0	49.5	19.0

Times shown are in **minutes**.

Notes:

[1] Average delay for each segment is the cumulative signal delay for bus route approaches to traffic signals on the segments defined in the table.

B. Ridership

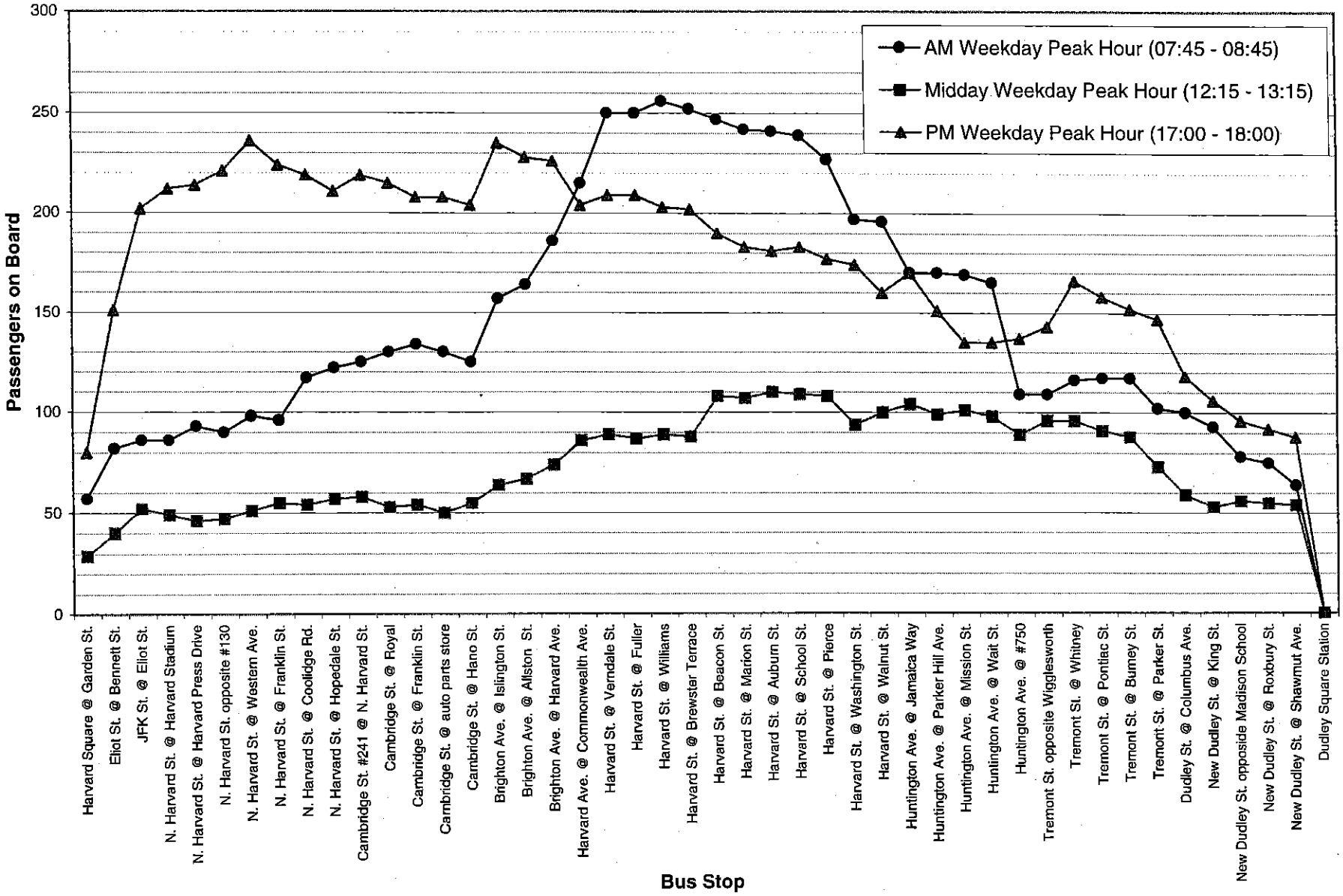
Figures 1 and 2 illustrate the distribution of passenger loads over the length of the route. The volume counts of passengers on board were calculated from 1997 ridecheck data of Bus Route 66[1] in the form of load profiles for the corridor-long traffic peak hours. The peak-hour passenger loads represent the total volume of about seven trips in each direction for the morning and the evening peak; for the midday peak, the passenger loads represent the total volume of about five trips in each direction.

Comments and Observations

The overall peak load segment in both directions occurs on Harvard Street between Babcock Street and Commonwealth Avenue. In the morning peak-hour, the inbound bus carries the highest number of passengers at one stretch, but outbound bus has high sustained ridership over the length of the route. The ridership for the inbound service during the evening peak-hour seems to reflect the outbound morning peak-hour ridership.

[1] Spring/Fall 1997 Comprehensive Ridecheck Program, CTPS/MBTA.

Figure 1. Distribution of Peak-Hour Passenger Loads--Inbound


AM Weekday Peak Hour (07:45 - 08:45)
Midday Weekday Peak Hour (12:15 - 13:15)
PM Weekday Peak Hour (17:00 - 18:00)
Passengers on Board
0
50
100
150
200
250
300
Harvard Square @ Garden St.
Eliot St. @ Bennett St.
JFK St. @ Eliot St.
N. Harvard St. @ Harvard Stadium
N. Harvard St. @ Harvard Press Drive
N. Harvard St. opposite #130
N. Harvard St. @ Western Ave.
N. Harvard St. @ Franklin St.
N. Harvard St. @ Coolidge Rd.
N. Harvard St. @ Hopedale St.
Cambridge St. #241 @ N. Harvard St.
Cambridge St. @ Royal
Cambridge St. @ Franklin St.
Cambridge St. @ auto parts store
Cambridge St. @ Hano St.
Brighton Ave. @ Islington St.
Brighton Ave. @ Allston St.
Brighton Ave. @ Harvard Ave.
Harvard Ave. @ Commonwealth Ave.
Harvard St. @ Verndale St.
Harvard St. @ Fuller
Harvard St. @ Williams
Harvard St. @ Brewster Terrace
Harvard St. @ Beacon St.
Harvard St. @ Marion St.
Harvard St. @ Auburn St.
Harvard St. @ School St.
Harvard St. @ Pierce
Harvard St. @ Washington St.
Harvard St. @ Walnut St.
Huntington Ave. @ Jamaica Way
Huntington Ave. @ Parker Hill Ave.
Huntington Ave. @ Mission St.
Huntington Ave. @ Wait St.
Huntington Ave. @ #750
Tremont St. opposite Wigglesworth
Tremont St. @ Whitney
Tremont St. @ Pontiac St.
Tremont St. @ Burney St.
Tremont St. @ Parker St.
Dudley St. @ Columbus Ave.
New Dudley St. @ King St.
New Dudley St. opposide Madison School
New Dudley St. @ Roxbury St.
New Dudley St. @ Shawmut Ave.
Dudley Square Station
Bus Stop

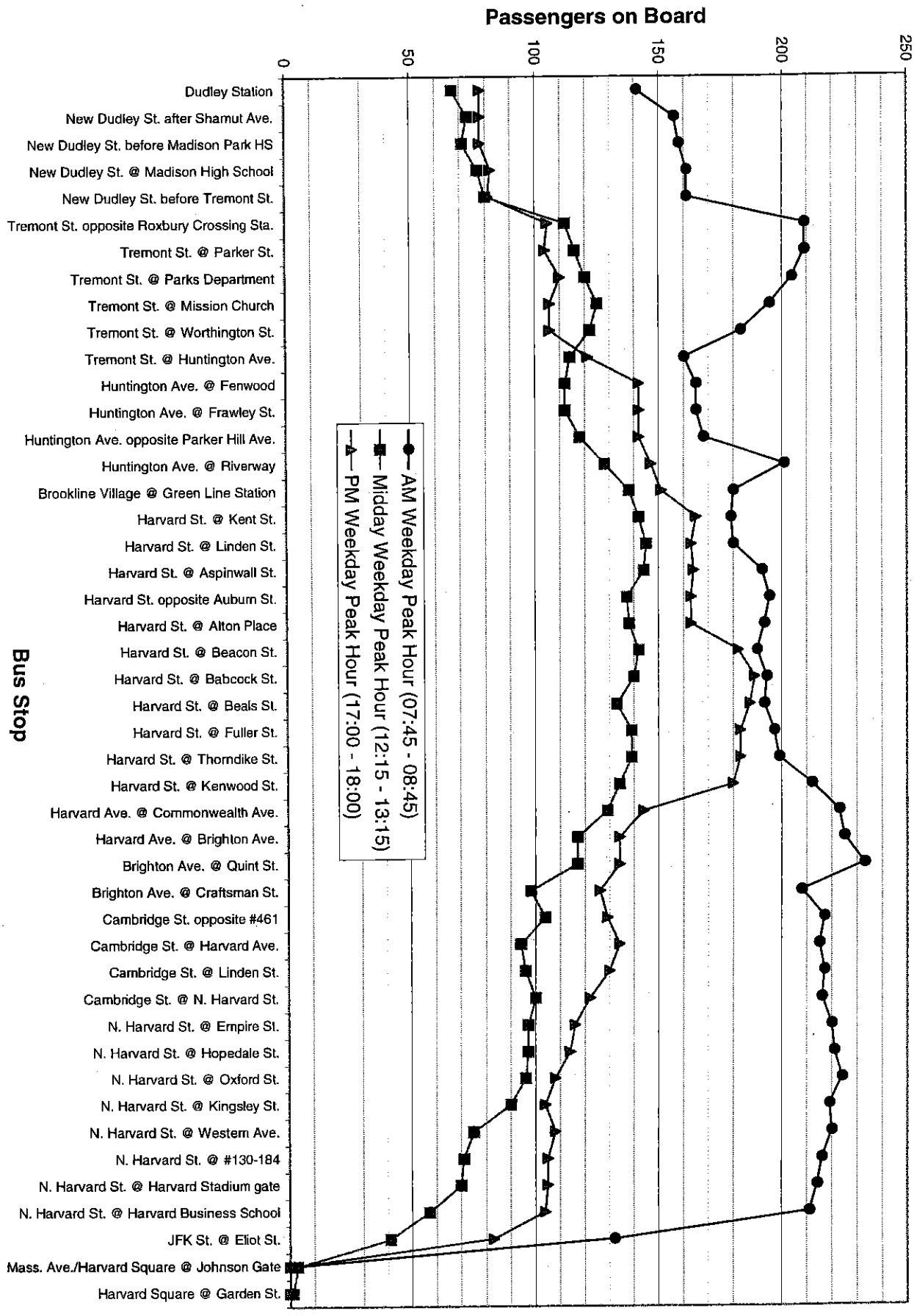
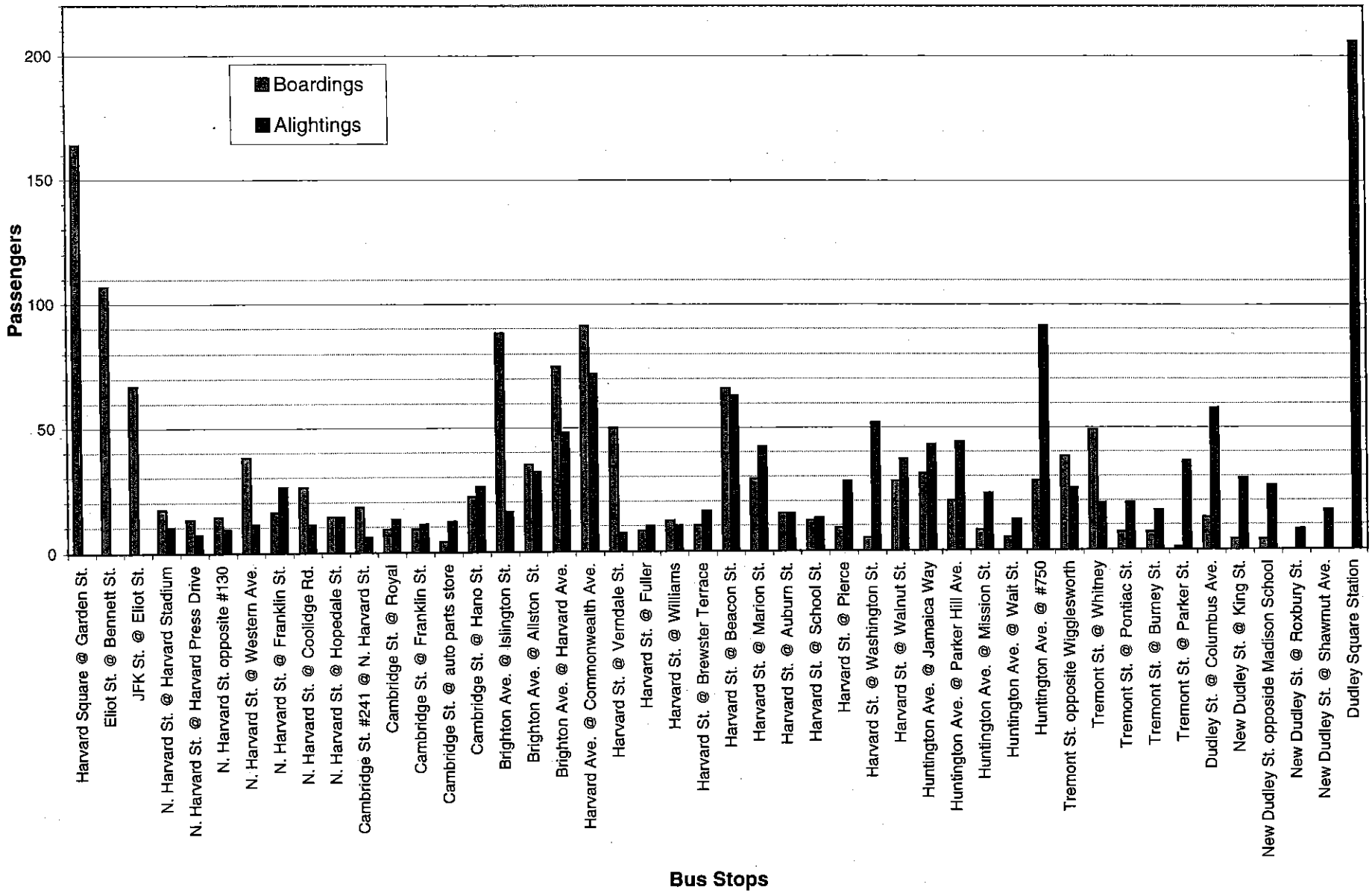

Passengers on Board
0
50
100
150
200
250
Bus Stop
Dudley Station
New Dudley St. after Shamut Ave.
New Dudley St. before Madison Park HS
New Dudley St. @ Madison High School
New Dudley St. before Tremont St.
Tremont St. opposite Roxbury Crossing Sta.
Tremont St. @ Parker St.
Tremont St. @ Parks Department
Tremont St. @ Mission Church
Tremont St. @ Worthington St.
Tremont St. @ Huntington Ave.
Huntington Ave. @ Fenwood
Huntington Ave. @ Frawley St.
Huntington Ave. opposite Parker Hill Ave.
Huntington Ave. @ Riverway
Brookline Village @ Green Line Station
Harvard St. @ Kent St.
Harvard St. @ Linden St.
Harvard St. @ Aspinwall St.
Harvard St. opposite Auburn St.
Harvard St. @ Alton Place
Harvard St. @ Beacon St.
Harvard St. @ Babcock St.
Harvard St. @ Beals St.
Harvard St. @ Fuller St.
Harvard St. @ Thorndike St.
Harvard St. @ Kenwood St.
Harvard Ave. @ Commonwealth Ave.
Harvard Ave. @ Brighton Ave.
Brighton Ave. @ Quint St.
Brighton Ave. @ Craftsman St.
Cambridge St. opposite #461
Cambridge St. @ Harvard Ave.
Cambridge St. @ Linden St.
Cambridge St. @ N. Harvard St.
N. Harvard St. @ Empire St.
N. Harvard St. @ Hopedale St.
N. Harvard St. @ Oxford St.
N. Harvard St. @ Kingsley St.
N. Harvard St. @ Western Ave.
N. Harvard St. @ #130-184
N. Harvard St. @ Harvard Stadium gate
N. Harvard St. @ Harvard Business School
JFK St. @ Eliot St.
Mass. Ave./Harvard Square @ Johnson Gate
Harvard Square @ Garden St.
AM Weekday Peak Hour (07:45 - 08:45)
Midday Weekday Peak Hour (12:15 - 13:15)
PM Weekday Peak Hour (17:00 - 18:00)

Figure 2. Distribution of Peak-Hour Passenger Loads--Outbound

C. Bus Stop Activity

The boardings and alightings at each bus stop are displayed in Figures 3 and 4. The volumes of passengers boarding and alighting by stop are from Spring 1998 ridecheck load profiles.

Figure 3. Combined (AM, Midday, PM) Peak-Hour Boardings and Alightings--Inbound


Boardings
Alightings
Passengers
0
50
100
150
200
Harvard Square @ Garden St.
Eliot St. @ Bennett St.
JFK St. @ Eliot St.
N. Harvard St. @ Harvard Stadium
N. Harvard St. @ Harvard Press Drive
N. Harvard St. opposite #130
N. Harvard St. @ Western Ave.
N. Harvard St. @ Franklin St.
N. Harvard St. @ Coolidge Rd.
N. Harvard St. @ Hopedale St.
Cambridge St. #241 @ N. Harvard St.
Cambridge St. @ Royal
Cambridge St. @ Franklin St.
Cambridge St. @ auto parts store
Cambridge St. @ Hano St.
Brighton Ave. @ Islington St.
Brighton Ave. @ Allston St.
Brighton Ave. @ Harvard Ave.
Harvard Ave. @ Commonwealth Ave.
Harvard St. @ Verndale St.
Harvard St. @ Fuller
Harvard St. @ Williams
Harvard St. @ Brewster Terrace
Harvard St. @ Beacon St.
Harvard St. @ Marion St.
Harvard St. @ Auburn St.
Harvard St. @ School St.
Harvard St. @ Pierce
Harvard St. @ Washington St.
Harvard St. @ Walnut St.
Huntington Ave. @ Jamaica Way
Huntington Ave. @ Parker Hill Ave.
Huntington Ave. @ Mission St.
Huntington Ave. @ Wait St.
Huntington Ave. @ #750
Tremont St. opposite Wigglesworth
Tremont St. @ Whitney
Tremont St. @ Pontiac St.
Tremont St. @ Burney St.
Tremont St. @ Parker St.
Dudley St. @ Columbus Ave.
New Dudley St. @ King St.
New Dudley St. opposide Madison School
New Dudley St. @ Roxbury St.
New Dudley St. @ Shawmut Ave.
Dudley Square Station
Bus Stops

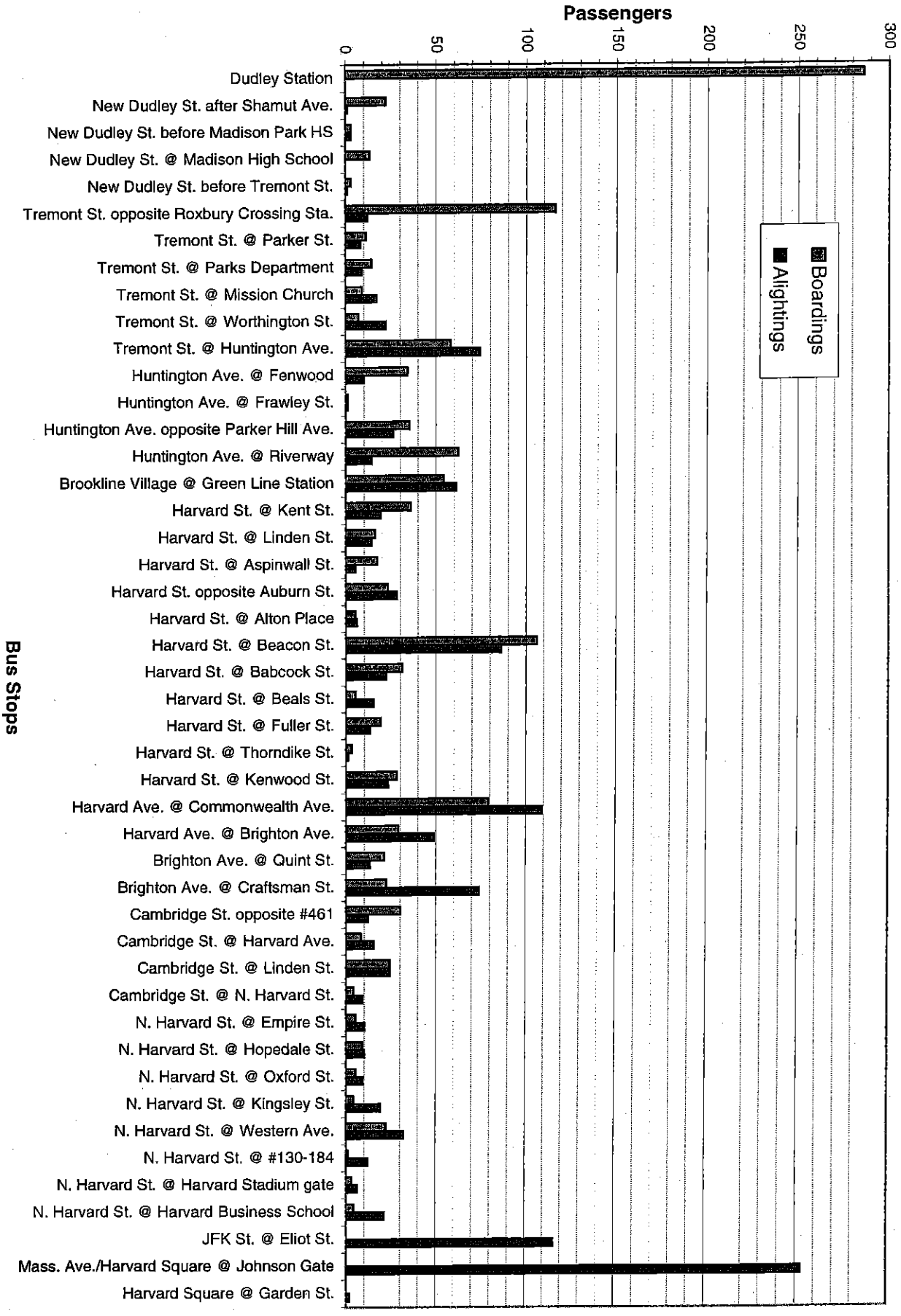

Passengers
0
50
100
150
200
250
300
Boardings
Alightings
Bus Stops
Dudley Station
New Dudley St. after Shamut Ave.
New Dudley St. before Madison Park HS
New Dudley St. @ Madison High School
New Dudley St. before Tremont St.
Tremont St. opposite Roxbury Crossing Sta.
Tremont St. @ Parker St.
Tremont St. @ Parks Department
Tremont St. @ Mission Church
Tremont St. @ Worthington St.
Tremont St. @ Huntington Ave.
Huntington Ave. @ Fenwood
Huntington Ave. @ Frawley St.
Huntington Ave. opposite Parker Hill Ave.
Huntington Ave. @ Riverway
Brookline Village @ Green Line Station
Harvard St. @ Kent St.
Harvard St. @ Linden St.
Harvard St. @ Aspinwall St.
Harvard St. opposite Auburn St.
Harvard St. @ Alton Place
Harvard St. @ Beacon St.
Harvard St. @ Babcock St.
Harvard St. @ Beals St.
Harvard St. @ Fuller St.
Harvard St. @ Thorndike St.
Harvard St. @ Kenwood St.
Harvard Ave. @ Commonwealth Ave.
Harvard Ave. @ Brighton Ave.
Brighton Ave. @ Quint St.
Brighton Ave. @ Craftsman St.
Cambridge St. opposite #461
Cambridge St. @ Harvard Ave.
Cambridge St. @ Linden St.
Cambridge St. @ N. Harvard St.
N. Harvard St. @ Empire St.
N. Harvard St. @ Hopedale St.
N. Harvard St. @ Oxford St.
N. Harvard St. @ Kingsley St.
N. Harvard St. @ Western Ave.
N. Harvard St. @ #130-184
N. Harvard St. @ Harvard Stadium gate
N. Harvard St. @ Harvard Business School
JFK St. @ Eliot St.
Mass. Ave./Harvard Square @ Johnson Gate
Harvard Square @ Garden St.

Figure 4. Combined (AM, Midday, PM) Peak-Hour Boardings and Alightings--Outbound

D. Passenger Loading

Tables 4 and 5 contain passenger load profiles, from the 1996 and the 1997 ridecheck surveys, based on bus trips sampled in the peak hour of the morning, midday, and evening time periods. The statistic reported is the ratio of passengers on board to number of seats on the bus following each bus stop. All instances where the number of passengers on board equaled or exceeded the number of seats are highlighted. These cases represent the areas of the route where passengers were standing. Instances where the passengers on board equaled or exceeded the loading standard are in boldface print.

Areas of Passenger Crowding by Time Period				PM Peak									
Seq	Stop ID	Description	7:40 AM	5:00 PM	5:10 PM	5:20 PM	5:20 PM	5:30 PM	5:30 PM	5:40 PM	5:40 PM	5:50 PM
1	22549	Harvard Square @ Garden St	0.24	0.21	0.42	0.81	0.28	0.21	0.67	0.43	0.00	0.10
2	32549	Eliot St. @ Bennett St.	0.24	0.30	0.72	1.10	0.28	0.48	1.00	0.98	0.02	0.17
3	2550	JFK St @ Eliot St	0.24	0.42	0.79	1.21	0.37	0.69	1.19	1.00	0.12	0.21
4	2551	N. Harvard St @ Harvard Staduim	0.21	0.42	0.84	1.21	0.42	0.69	1.21	1.12	0.23	0.21
5	2552	N. Harvard St @ Harvard Press Drive	0.21	0.42	0.84	1.26	0.42	0.64	1.24	1.17	0.26	0.21
6	9584	N. Harvard St @ Western Ave	0.19	0.44	0.95	1.24	0.40	0.79	1.40	1.14	0.35	0.29
7	2553	N Harvard St @ Franklin St	0.19	0.33	0.95	1.26	0.40	0.81	1.40	1.07	0.30	0.29
8	2554	N Harvard St @ Coolidge Rd	0.31	0.30	0.95	1.24	0.37	0.79	1.44	1.10	0.28	0.29
9	2555	N Harvard St @ Hopedale St	0.31	0.33	0.88	1.12	0.37	0.79	1.42	1.07	0.28	0.24
10	2556	N Harvard St (opp #130)	0.33	0.33	0.88	1.12	0.37	0.79	1.42	1.07	0.30	0.21
11	1191	Cambridge St #241 @ N Harvard St	0.33	0.33	0.91	1.19	0.37	0.76	1.45	1.10	0.30	0.19
12	1192	Cambridge St @ Royal	0.33	0.30	0.84	1.14	0.33	0.79	1.44	1.09	0.30	0.19
13	1193	Cambridge St @ Franklin St	0.33	0.30	0.81	1.14	0.33	0.74	1.35	1.09	0.30	0.19
14	1194	Cambridge St @ Auto parts store	0.33	0.30	0.81	1.14	0.28	0.74	1.35	1.00	0.28	0.19
15	1195	Cambridge St @ Hano St	0.33	0.30	0.81	1.17	0.28	0.67	1.28	1.00	0.30	0.19
16	1594	Brighton Ave @ Islington St	0.40	0.37	0.88	1.29	0.37	0.76	1.42	1.07	0.30	0.50
17	1590	Brighton Ave @ Alston St	0.40	0.33	0.88	1.19	0.37	0.74	1.33	1.00	0.30	0.64
18	1591	Brighton Ave @ Harvard Ave	0.43	0.37	0.91	1.27	0.28	0.71	1.26	1.05	0.28	0.64
19	1302	Harvard Ave @ Comm Ave	0.60	0.35	0.93	1.02	0.44	0.69	0.93	0.88	0.19	0.81
20	11302	Harvard St @ Verndal St	0.69	0.42	0.95	1.00	0.47	0.71	0.93	0.90	0.19	0.88
21	1304	Harvard Ave @ Thorndike	0.67	0.42	0.95	1.00	0.47	0.71	0.88	0.90	0.19	0.90
22	1305	Harvard Ave @ Fuller	0.69	0.40	0.95	1.00	0.47	0.67	0.84	0.90	0.19	0.86
23	1306	Harvard Ave @ Williams	0.69	0.37	0.98	1.00	0.47	0.67	0.84	0.90	0.19	0.83
24	1307	Harvard Ave @ Brewster Terrace	0.67	0.37	0.98	0.98	0.47	0.55	0.79	0.86	0.16	0.90
25	1308	Harvard Ave @ Beacon St	0.76	0.35	0.98	0.90	0.58	0.50	0.60	0.83	0.16	0.95
26	1309	Harvard Ave @ Marion St	0.76	0.33	1.00	0.93	0.56	0.50	0.60	0.79	0.16	1.00
27	1310	Harvard Ave @ Auburn St	0.76	0.28	1.00	0.88	0.53	0.52	0.58	0.83	0.16	0.92
28	1311	Harvard Ave @ School St	0.76	0.28	0.98	0.83	0.49	0.52	0.56	0.83	0.16	0.95
29	1312	Harvard Ave @ Pierce	0.76	0.28	0.93	0.79	0.47	0.50	0.56	0.83	0.16	0.95
30	1313	Harvard St @ Washington St	0.69	0.30	0.95	0.76	0.49	0.43	0.47	0.79	0.14	0.98
31	11313	Harvard Ave @ Walnut St	0.74	0.30	1.00	0.76	0.49	0.45	0.44	0.86	0.12	0.95
32	1314	Huntington Ave @ Jamaicaway	0.76	0.30	0.79	0.64	0.42	0.48	0.37	0.76	0.12	0.79
33	1315	Huntington Ave @ Parker Hill Ave	0.88	0.30	0.74	0.55	0.49	0.38	0.53	0.71	0.12	0.69
34	1316	Huntington Ave @ Mission St	0.86	0.30	0.74	0.55	0.49	0.38	0.47	0.71	0.12	0.71
35	1317	Huntington Ave @ Wait St	0.86	0.30	0.74	0.55	0.44	0.43	0.47	0.71	0.12	0.71
36	1318	Huntington Ave @ #750	0.69	0.30	0.93	0.55	0.23	0.52	0.47	0.76	0.07	0.74
37	1319	Tremont St @ Opp. Wigglesworth	0.67	0.40	0.93	0.64	0.33	0.48	0.49	0.83	0.12	0.93
38	1320	Tremont St @ Whitney	0.71	0.40	0.91	0.67	0.28	0.26	0.51	0.81	0.05	0.21
39	11320	Tremont St @ Pontiac St	0.79	0.40	0.95	0.64	0.33	0.24	0.51	0.79	0.05	0.14
40	21320	Tremont St @ Parker St	0.79	0.40	0.93	0.64	0.33	0.14	0.49	0.79	0.12	0.74
41	1322	New Dudley St @ Columbus Ave	0.79	0.21	0.65	0.64	0.28	0.14	0.40	0.79	0.09	0.14
42	1323	Tremont St @ Burney St	0.64	0.16	0.65	0.62	0.33	0.14	0.40	0.74	0.09	0.88
43	11257	New Dudley St. @ Opp Madison Park Schoo	0.60	0.16	0.65	0.55	0.35	0.14	0.33	0.71	0.05	0.88
44	1259	New Dudley St. @ King St.	0.55	0.16	0.60	0.45	0.35	0.14	0.30	0.57	0.05	0.88
45	11258	New Dudley St. @ Roxbury St.	0.55	0.16	0.60	0.43	0.35	0.14	0.16	0.50	0.05	0.88
46	11259	New Dudley St. @ Shawmut Ave.	0.52	0.16	0.58	0.33	0.35	0.14	0.16	0.50	0.05	0.88
47	64	Dudley Station	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Observations are from the 1996 and 1997 sets of data from the

Areas of Passenger Crowding by Time Period*

			PM Peak									
Seq	Stop ID	Description		5:10 PM	5:10 PM	5:20 PM	5:20 PM	5:30 PM	5:30 PM	5:40 PM	5:40 PM	5:50 PM	5:50 PM
1	64	Dudley Station	0.	0.19	0.00	0.43	0.00	0.14	0.00	0.43	0.00	0.38	0.00
2	11150	New Dudley St. @ after Shawmut Ave.	0.	0.19	0.47	0.43	0.16	0.14	0.14	0.45	0.35	0.38	0.09
3	11149	New Dudley St @ Madison Park High School	0.	0.19	0.49	0.43	0.16	0.14	0.14	0.45	0.35	0.38	0.09
4	11148	New Dudley St. @ John D. O'Bryant School	0.	0.19	0.51	0.43	0.16	0.14	0.14	0.48	0.37	0.45	0.09
5	41148	New Dudley St @ before Tremont	0.	0.19	0.51	0.40	0.16	0.14	0.14	0.48	0.37	0.45	0.09
6	1357	Tremont St @ Opp. Roxbury Crossing Station	0.	0.43	0.51	0.40	0.16	0.12	0.14	0.64	0.35	0.52	0.09
7	11358	Tremont St @ Parker St	0.	0.38	0.60	0.40	0.12	0.17	0.16	0.67	0.44	0.52	0.09
8	1359	Tremont St @ Parks Department	0.	0.38	0.60	0.40	0.09	0.17	0.14	0.81	0.44	0.52	0.09
9	1360	Tremont St @ Mission Church	0.	0.38	0.60	0.38	0.09	0.14	0.12	0.81	0.44	0.45	0.09
10	1361	Tremont St @ Worthington St	0.	0.38	0.58	0.38	0.09	0.14	0.12	0.81	0.42	0.45	0.09
11	1362	Tremont St @ Huntington Ave	0.	0.31	0.58	0.67	0.09	0.19	0.12	0.74	0.35	0.55	0.09
12	1363	Huntington Ave @ Fenwood	0.	0.36	0.84	0.95	0.14	0.21	0.37	0.79	0.58	0.52	0.09
13	11363	Huntington Ave @ Opp. Parker Hill Ave	0.	0.36	0.98	0.95	0.26	0.21	0.42	0.79	0.60	0.52	0.14
14	1365	Huntington Ave @ Frawley St	0.	0.36	0.88	1.02	0.23	0.21	0.44	0.71	0.67	0.45	0.14
15	1366	Huntington Ave @ Riverway	0.	0.29	0.88	1.13	0.23	0.24	0.44	0.79	0.67	0.45	0.14
16	11366	Brookline Village @ Green Line Station	0.	0.29	0.95	1.02	0.26	0.21	0.49	0.74	0.67	0.52	0.14
17	1367	Harvard St @ Kent St	0.	0.38	0.98	1.17	0.26	0.21	0.47	0.83	0.70	0.52	0.14
18	1368	Harvard St @ Linden St	0.	0.38	1.00	1.19	0.26	0.26	0.47	0.83	0.72	0.45	0.14
19	1369	Harvard St @ Aspinwall St	0.	0.38	1.02	1.19	0.23	0.29	0.44	0.86	0.72	0.45	0.14
20	1370	Harvard St @ opp Auburn St	0.	0.38	1.05	1.19	0.23	0.29	0.42	0.83	0.72	0.40	0.14
21	1371	Harvard St @ Alton Place	0.	0.38	1.07	1.19	0.23	0.29	0.44	0.83	0.72	0.40	0.14
22	1372	Harvard St @ Beacon St	0.	0.38	1.12	1.19	0.23	0.21	0.44	0.86	0.84	0.55	0.14
23	1373	Harvard St @ Babcock St	0.	0.38	1.12	0.90	0.19	0.26	0.40	0.88	0.81	0.55	0.14
24	1374	Harvard St @ Beals St	0.	0.38	1.12	0.88	0.16	0.26	0.40	0.86	0.84	0.50	0.14
25	1375	Harvard St @ Fuller St	0.	0.38	1.07	0.88	0.16	0.26	0.47	0.83	0.88	0.48	0.14
26	1376	Harvard St @ Thorndike St	0.	0.38	1.12	0.88	0.14	0.26	0.44	0.83	0.93	0.48	0.19
27	1377	Harvard St @ Kenwood St	0.	0.45	1.14	0.83	0.14	0.26	0.40	0.79	0.93	0.50	0.16
28	1378	Harvard St @ Comm Ave	0.	0.50	1.05	0.55	0.12	0.19	0.30	0.62	0.84	0.50	0.16
29	1379	Harvard St @ Brighton Ave	0.	0.50	0.98	0.50	0.12	0.29	0.30	0.50	0.72	0.36	0.33
30	964	Brighton Ave @ Quint St	0.	0.60	0.91	0.48	0.05	0.24	0.33	0.50	0.63	0.36	0.33
31	1380	Brighton Ave @ Craftsman St	0.	0.60	0.93	0.38	0.05	0.24	0.30	0.45	0.65	0.36	0.37
32	1111	Cambridge St @ opp #461	0.	0.60	1.05	0.40	0.05	0.24	0.30	0.45	0.58	0.26	0.40
33	1112	Cambridge St @ Harvard Ave	0.	0.60	1.05	0.45	0.05	0.24	0.30	0.45	0.60	0.26	0.40
34	1113	Cambridge St @ Linden St	0.	0.55	1.05	0.45	0.07	0.24	0.30	0.45	0.60	0.26	0.40
35	1114	Cambridge St @ N Harvard St	0.	0.55	1.05	0.33	0.12	0.17	0.30	0.45	0.53	0.26	0.44
36	2558	N Harvard St @ Empire St	0.	0.55	1.05	0.31	0.12	0.17	0.30	0.43	0.53	0.26	0.44
37	9426	N Harvard St @ Hopedale St	0.	0.55	1.00	0.31	0.12	0.17	0.30	0.38	0.51	0.21	0.42
38	2559	N Harvard St @ Kingsley St	0.	0.55	1.00	0.21	0.09	0.17	0.30	0.33	0.51	0.21	0.44
39	2560	N Harvard St @ Oxford St	0.	0.55	0.95	0.21	0.12	0.17	0.30	0.31	0.56	0.21	0.42
40	2561	N Harvard St @ Western Ave	0.	0.55	0.88	0.26	0.12	0.14	0.28	0.31	0.56	0.31	0.42
41	2562	N Harvard St #130-184	0.	0.48	0.81	0.26	0.12	0.17	0.26	0.29	0.56	0.31	0.42
42	2563	N Harvard St @ Harvard Stadium gate	0.	0.48	0.86	0.26	0.12	0.17	0.26	0.29	0.63	0.31	0.42
43	2564	N Harvard St @ Harvard Business School	0.	0.48	0.86	0.26	0.09	0.14	0.23	0.26	0.63	0.38	0.42
44	2565	JFK St @ Eliot St	0.	0.45	0.86	0.17	0.09	0.14	0.21	0.12	0.63	0.38	0.42
45	12549	Mass Ave/Harvard Square @ Johnson Gate	0.	0.00	0.21	0.00	0.07	0.00	0.21	0.00	0.44	0.00	0.42
46	22549	Harvard Square @ Garden St	0.	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.44	0.00	0.00

* Observations are from the 1996 and 1997 sets of data from th

E. Passenger-Hours of Delay

Bus passengers are affected by both delay at traffic signals and the delay caused by parking movements. While parking movement delay can impede bus service performance, this measure is not easily quantified. So, instead, the study focused on quantifying the effect of traffic signal delay. As such, the passenger-hours of delay are based only on the traffic signal level-of-service calculations.

Vehicle delay is typically expressed as an average in seconds; it is measured by approach to an intersection, across a peak hour.[2] The average delay is applicable to every vehicle in the approach queue. Generally, most cars in the queue have one person inside, so the delay affects one person per vehicle. Since the seconds of delay apply to each passenger on the bus at an approach to the intersection, the result is a measure of passenger-hours of delay.

Tables 6 and 7 list the inbound and outbound peak-hour passengers on board at key intersections (those analyzed with Highway Capacity Software). For each intersection, the table presents the average delay faced by vehicles in the lane group the buses use and the passenger-hours of delay for buses at the intersections. The passenger-hours of delay shown in the table, then, is the count of peak-hour passengers on board at an approach to a signalized intersection multiplied by the average seconds of traffic signal delay at the intersection for the bus route lane group. Hence, an intersection may not have a high delay per vehicle, yet it could have high delay per passenger due to the number of transit users at the location. Similarly, even if only a moderate number of passengers are on board at an intersection, the passenger-hours of delay could be quite high if the intersection has a poor level-of-service.

Figures 5 and 6 illustrate the traffic signal-related passenger-hours of delay by peak hour for the inbound and outbound bus.

[2] Not all vehicles will experience the same delay, as it will vary from cycle to cycle depending on traffic volumes and other conflicts, but the average represents a general condition that is likely to occur.

Table 6. Passenger-Hours of Delay: INBOUND

Int #	Traffic Signal Location	A.M. Peak Hour			Midday Peak Hour			P.M. Peak Hour		
		Passgrs. on Board	Delay (min:sec)	Passgr.-Hrs Delay (hh:mm:ss)	Passgrs. on Board	Delay (min:sec)	Passgr.-Hrs Delay (hh:mm:ss)	Passgrs. on Board	Delay (min:sec)	Passgr.-Hrs Delay (hh:mm:ss)
55	Mass Ave @ Brattle St.	57	00:00	0:00:11	29	00:03	0:01:27	80	00:00	0:00:08
53	Eliot St @ JFK St	82	00:11	0:14:21	40	00:03	0:02:00	151	00:02	0:05:47
52	JFK @ Memorial Drive	86	02:00	2:52:00	52	02:00	1:44:00	202	02:00	6:44:00
51	JFK @ Soldiers Field Rd	86	00:23	0:33:24	52	00:14	0:11:58	202	01:08	3:48:56
50	N. Harvard St @ Western Ave	98	02:00	3:16:00	51	02:00	1:42:00	236	02:00	7:52:00
45	Cambridge St @ N Harvard St	122	00:42	1:26:01	57	00:23	0:21:45	211	00:29	1:40:13
43	Cambridge St @ Harvard St	134	01:06	2:27:24	54	00:24	0:21:31	208	01:06	3:48:48
42	Cambridge @ Brighton Ave	125	00:14	0:28:07	50	00:15	0:12:35	204	00:18	1:00:52
40	Brighton Ave @ Allston St	164	00:01	0:03:50	64	00:01	0:01:23	228	00:01	0:04:56
39	Brighton Ave @ Harvard Ave	186	00:16	0:50:13	67	*00:17*	0:18:59	226	00:20	1:15:43
38	Harvard Ave @ Commonwealth Ave	215	00:23	1:22:25	74	00:23	0:28:22	204	00:22	1:16:10
37	Harvard St @ Verndale St	250	00:03	0:12:55	86	00:01	0:01:26	209	02:00	6:58:00
33	Harvard St @ Fuller	250	00:14	0:57:05	87	00:06	0:08:16	203	00:07	0:23:21
32	Harvard St @ Steadman/Williams	256	00:04	0:17:04	89	*00:14*	0:20:46	202	00:04	0:12:48
31	Harvard St @ Babcock St	252	00:11	0:46:12	88	00:09	0:13:12	190	00:11	0:33:34
30	Harvard St @ Beacon St	247	00:23	1:36:44	108	00:13	0:23:24	183	00:29	1:28:09
21	Harvard St @ Aspinwall/School St	239	00:39	2:34:09	109	00:29	0:52:41	177	02:00	5:54:00
19	Harvard St @ Washington St/Davis/Kent	197	00:08	0:26:16	94	00:10	0:15:49	160	00:11	0:28:48
17	Washington @ Boylston St	196	00:43	2:19:29	100	01:25	2:21:40	170	01:15	3:32:30
16	Boylston St @ Brookline Ave	196	00:10	0:32:40	100	*00:01*	0:01:40	170	00:17	0:47:02
13	Huntington Ave @ S. Huntington Ave	170	00:33	1:33:30	104	*00:01*	0:01:44	151	00:28	1:10:28
12	Huntington Ave @ Parker Hill Ave	170	00:04	0:11:20	99	*00:03*	0:04:57	135	00:01	0:02:15
10	Huntington Ave @ Tremont St	109	00:29	0:53:03	89	00:21	0:31:09	143	02:00	4:46:00
8	Tremont St@ St Alphonsus St.	116	00:22	0:42:44	96	00:13	0:20:48	158	00:38	1:41:07
6	Tremont St @ Parker St	102	00:09	0:15:18	73	*00:03*	0:03:39	147	02:00	4:54:00
5	Tremont St @ New Dudley St/Columbus Ave	100	00:31	0:51:40	59	00:23	0:22:37	118	00:41	1:20:38
3	New Dudley St @ Shawmut Ave/Roxbury St	75	00:13	0:16:15	55	00:11	0:10:05	92	00:13	0:19:56
2	New Dudley St @ Washington St	64	00:23	0:24:32	54	00:08	0:07:12	88	00:14	0:20:32
1	Dudley St @ Warren St	64	00:26	0:27:44	54	00:54	0:48:20	88	00:54	1:18:37
	Totals		13:01	28:52:37		11:08	12:37:11		21:28	63:49:17

Table 7. Passenger-Hours of Delay: OUTBOUND

Int #	Traffic Signal Location	A.M. Peak Hour			Midday Peak Hour			P.M. Peak Hour		
		A.M. Passgrs. on Board	A.M. Delay (min:sec)	Passgr.-Hrs Delay (hh:mm:ss)	Midday Passgrs. on Board	Midday Delay (min:sec)	Passgr.-Hrs Delay (hh:mm:ss)	P.M. Passgrs. On Board	P.M. Delay (min:sec)	Passgr.-Hrs Delay (hh:mm:ss)
2	Washington Street @ New Dudley Street	141	00:15	0:35:15	67	00:07	0:07:49	78	00:07	0:09:06
3	New Dudley St. @ Shawmut Ave.	141	00:15	0:35:15	67	00:12	0:13:24	78	00:13	0:16:54
5	New Dudley St/Tremont St/New Columbus A	161	00:34	1:31:14	80	00:15	0:20:00	81	00:52	1:10:12
6	Tremont Street @ Parker St	209	00:04	0:13:56	116		0:00:00	104	02:00	3:28:00
8	Tremont Street @ St. Alphonsus St.	204	00:11	0:37:24	120	00:22	0:44:00	110	02:00	3:40:00
10	Tremont St @ Huntington Ave	160	01:09	3:04:00	114	00:39	1:14:06	121	00:56	1:52:56
11	Huntington Ave @ Fenwood	160	00:01	0:02:40	114		0:00:00	121	00:01	0:02:01
12	Huntington Ave at Parker Hill	168	00:03	0:08:24	118		0:00:00	142	00:17	0:40:14
13	Huntington Ave @ S. Huntington	168	00:22	1:01:36	118		0:00:00	142	02:00	4:44:00
16	Washington St and Brookline Ave	201	00:29	1:37:09	128		0:00:00	147	00:36	1:28:12
17	Washington St @ Boylston St	180	00:14	0:42:00	138	00:13	0:29:54	151	00:27	1:07:57
19	Harvard St/Washington St/Davis St/Kent St	180	00:09	0:27:00	138	00:13	0:29:54	151	00:31	1:18:01
21	Harvard St @ Aspinwall St/School St	180	02:00	6:00:00	145	02:00	4:50:00	163	02:00	5:26:00
30	Harvard St @ Beacon St (Coolidge Corner)	190	00:35	1:50:50	142	00:17	0:40:14	182	00:33	1:40:06
31	Harvard St @ Babcock St	190	00:21	1:06:30	142	00:19	0:44:58	182	00:20	1:00:40
32	Harvard St @ Stedman	194	00:11	0:35:34	140		0:00:00	189	02:00	6:18:00
33	Harvard St @ Fuller St	193	00:05	0:16:05	133	00:06	0:13:18	187	00:04	0:12:28
37	Harvard St @ Verndale	212	00:05	0:17:40	134	00:02	0:04:28	180	00:06	0:18:00
38	Harvard Ave. @ Commonwealth Ave.	223	00:25	1:32:55	129	00:26	0:55:54	144	01:28	3:31:12
39	Harvard Ave. @ Brighton Ave.	225	00:26	1:37:30	117		0:00:00	134	00:56	2:05:04
40	Brighton Ave @ Allston St.	233	00:02	0:07:46	117	00:02	0:03:54	134	00:03	0:06:42
42	Brighton Ave @ Cambridge St (free right)	208	00:23	1:18:21	98	00:22	0:35:46	126	00:29	1:00:54
43	Cambridge St @ Harvard Ave	215	00:22	1:17:24	94	00:18	0:28:12	134	00:21	0:45:47
45	Cambridge St @ N Harvard St	216	01:39	5:56:24	100	02:44	4:33:20	122	02:00	4:04:00
50	N Harvard St @ Western Ave	219	02:00	7:18:00	90	01:05	1:37:12	104	02:00	3:28:00
51	N Harvard St @ Soldiers Field Rd	211	02:00	7:02:00	57	02:00	1:54:00	104	02:00	3:28:00
52	JFK St @ Memorial Dr	211	00:33	1:56:03	57	00:18	0:17:06	104	00:47	1:21:28
53	JFK St @ Eliot St	132	00:25	0:55:00	41	00:16	0:10:56	83	00:20	0:27:40
	Totals		15:17	49:43:55		12:16	20:49:47		25:27	55:11:34

Figure 5. Passenger-Hours of Delay (Inbound)

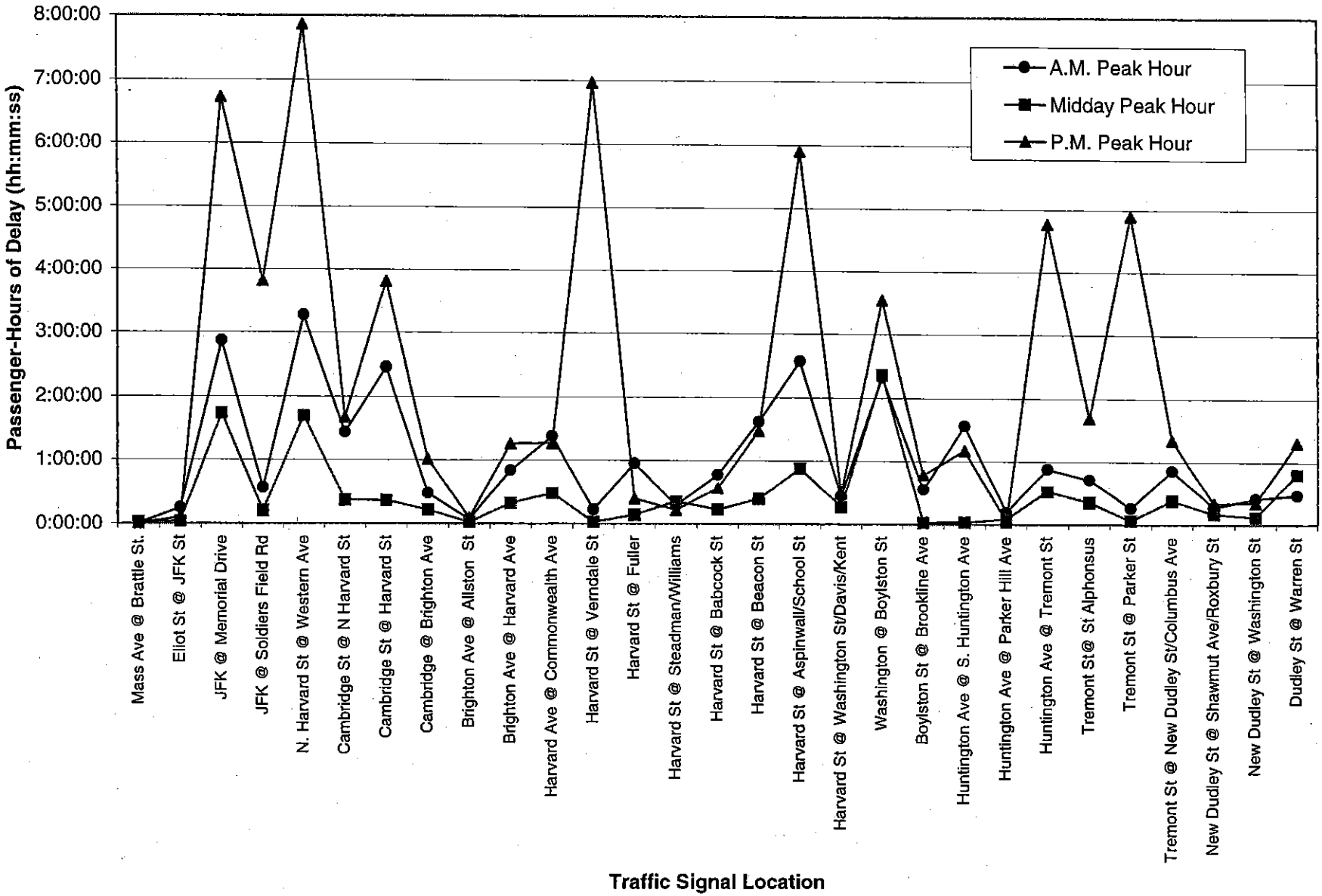
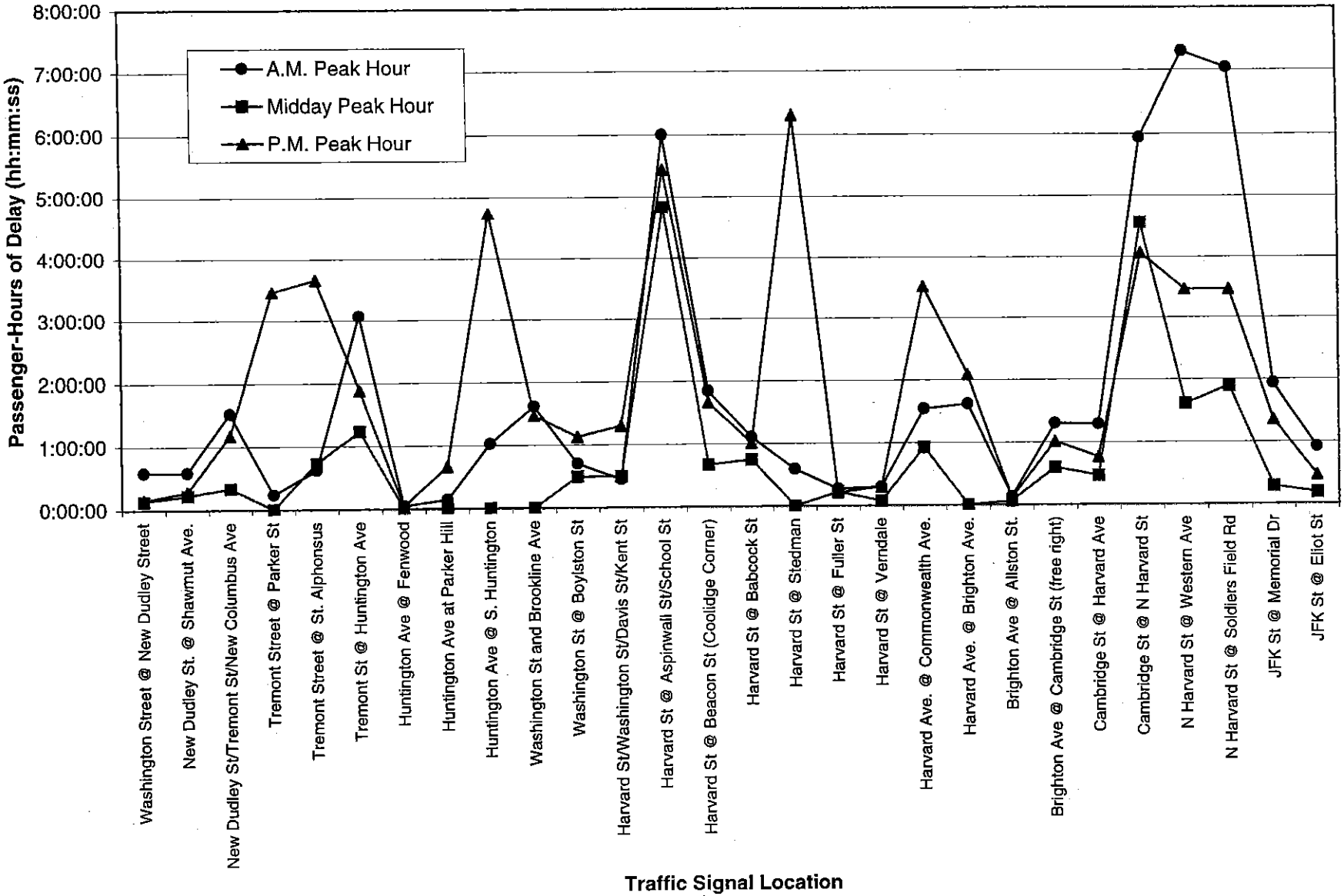

Passenger-Hours of Delay (hh:mm:ss)
8:00:00
7:00:00
6:00:00
5:00:00
4:00:00
3:00:00
2:00:00
1:00:00
0:00:00
A.M. Peak Hour
Midday Peak Hour
P.M. Peak Hour
Mass Ave @ Brattle St.
Eliot St @ JFK St
JFK @ Memorial Drive
JFK @ Soldiers Field Rd
N. Harvard St @ Western Ave
Cambridge St @ N Harvard St
Cambridge St @ Harvard St
Cambridge @ Brighton Ave
Brighton Ave @ Allston St
Brighton Ave @ Harvard Ave
Harvard Ave @ Commonwealth Ave
Harvard St @ Verndale St
Harvard St @ Fuller
Harvard St @ Steadman/Williams
Harvard St @ Babcock St
Harvard St @ Beacon St
Harvard St @ Aspinwall/School St
Harvard St @ Washington St/Davis/Kent
Washington @ Boylston St
Boylston St @ Brookline Ave
Huntington Ave @ S. Huntington Ave
Huntington Ave @ Parker Hill Ave
Huntington Ave @ Tremont St
Tremont St@ St Alphonsus
Tremont St @ Parker St
Tremont St @ New Dudley St/Columbus Ave
New Dudley St @ Shawmut Ave/Roxbury St
New Dudley St @ Washington St
Dudley St @ Warren St
Traffic Signal Location

Figure 6. Passenger-Hours of Delay (Outbound)


8:00:00
7:00:00
6:00:00
5:00:00
4:00:00
3:00:00
2:00:00
1:00:00
0:00:00
Passenger-Hours of Delay (hh:mm:ss)
A.M. Peak Hour
Midday Peak Hour
P.M. Peak Hour
Washington Street @ New Dudley Street
New Dudley St. @ Shawmut Ave.
New Dudley St/Tremont St/New Columbus Ave
Tremont Street @ Parker St
Tremont Street @ St. Alphonsus
Tremont St @ Huntington Ave
Huntington Ave @ Fenwood
Huntington Ave at Parker Hill
Huntington Ave @ S. Huntington
Washington St and Brookline Ave
Washington St @ Boylston St
Harvard St/Washington St/Davis St/Kent St
Harvard St @ Aspinwall St/School St
Harvard St @ Beacon St (Coolidge Corner)
Harvard St @ Babcock St
Harvard St @ Stedman
Harvard St @ Fuller St
Harvard St @ Verndale
Harvard Ave. @ Commonwealth Ave.
Harvard Ave. @ Brighton Ave.
Brighton Ave @ Allston St.
Brighton Ave @ Cambridge St (free right)
Cambridge St @ Harvard Ave
Cambridge St @ N Harvard St
N Harvard St @ Western Ave
N Harvard St @ Soldiers Field Rd
JFK St @ Memorial Dr
JFK St @ Eliot St
Traffic Signal Location

Appendix C:

Field Observations of the Corridor

Appendix C

Field Observations of the Corridor

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Introduction

CTPS performed a field reconnaissance of the bus route to detail the kinds of problems occurring at intersections and along the roadway segments. In addition to observed traffic and pedestrian activity and behavior, included are the observations of the existing on street parking along the route—noting whether and where it was permitted, metered, or prohibited.

The observations are listed in geographic sequence by segment and intersection, following the outbound path of the bus route, from Dudley Square to Harvard Square.

A. Roxbury

The bus route has three segments in Roxbury. Buses leave Dudley Square on Dudley/New Dudley Street, travel west on Tremont Street at Roxbury Crossing, and continue west on Huntington Avenue at Brigham Circle. (Dudley Square was reconstructed in the 1980s to improve the traffic management.)

Dudley/New Dudley Street

Dudley Square is the transfer center for 15 bus routes, many with frequent headways. During the peak hours of travel activity, the intersections in Dudley Square serve well over 60 buses. The area is experiencing an economic development renaissance since the reconstruction of Dudley Station and the construction of the police station, the post office, and the Reggie Lewis Athletic Center. As a result, traffic demand is increasing, seemingly beyond the capacity of the intersections in the square.

On Dudley Street two-hour on-street parking for about six cars is permitted on the westbound side of the street between Warren Street and the Dudley Station exit. On the eastbound side, the police station has angled parking facing into the street for about twenty cars. Parking is not permitted from Shawmut Avenue to Tremont Street westbound. Eastbound, parking appears to be unrestricted, except for street cleaning periods and bus stops.

Warren Street at Dudley Street

Significant traffic queues build on all approaches to the intersection of Warren Street and Dudley Street. The right turn from Dudley Street eastbound to Warren Street is constructed as a free right turn. However, when the actuated exclusive pedestrian phase on Dudley Street is called, right turns are stopped, thus causing traffic queues to block the nearby intersection of Dudley Street with Washington Street to the west. Furthermore, often, the pedestrians hit the call button, but proceed across the intersection without waiting for the pedestrian phase. So, the right turns are delayed without purpose.

Vehicles leaving from the parking spaces between Warren Street and the Dudley Station exit can enter the traffic stream at any point along the segment. The frequent parking maneuvers may contribute to the delay experienced along this stretch of Dudley Street.

Washington Street at Dudley Street

The intersection of Dudley Street at Washington Street suffers from high volumes of westbound left turns to Washington Street southbound. The traffic forms queues in the left and through shared lane that extend back almost to Warren Street, leaving very little room to absorb the left turns from Warren Street. In addition, eastbound traffic queues from the intersection of Dudley Street at Warren Street extend through the Washington Street intersection, thus effectively blocking the westbound lefts. The short segment between Warren Street and Washington Street quickly fills with buses making left turns out of Washington Street southbound.

New Dudley Street West of Shawmut Avenue

From Shawmut Avenue to Tremont Street westbound, signage indicates that parking is not permitted; however, cars are routinely parked there. Several closely spaced bus stops located along this segment are generally blocked by parked cars. Eastbound, there does not appear to be any restriction on parking, except for street cleaning periods and at bus stops. A "Right Turn Only" lane approaching Roxbury Street is defined only by signs; the road is not striped for a right turn-lane, and nothing differentiates the lane from what is treated as the parking lane.

When school lets out at Madison Park High School, pedestrian activity in the area of the crosswalk is quite extensive as students board the buses for home. Delay to traffic flow results from students crossing the street. Further delay results from buses double-parked alongside New Dudley Street waiting for students to be released from school.

Tremont Street

Tremont Street passes through a densely populated area, bordering the Mission Hill neighborhood. The road maintains a single lane in each direction, frequently interrupted with curb cuts. Overall, Tremont Street appears congested and cluttered.

At the Roxbury Crossing T station and bus stop on Tremont Street, parking is restricted to one half hour on both sides of the street. Continuing up to Worthington Street, two-hour general parking is permitted on both sides of the street. Between Worthington Street and Wigglesworth Street, parking on Tremont Street is restricted to resident permit parking only.

In general, parking spaces are not defined well and are not metered; parking restrictions and permissions are very unclear. Many signs indicating tow zones and bus stops line Tremont Street northbound, but cars are frequently parked there anyway. Several bus stops are located quite close together over the length of Tremont Street; drivers tend to park their cars in every bus stop. Southbound, from Huntington Avenue toward Wigglesworth Street, a bus stop between the entrance and exit to the Osco Drug Plaza is clearly marked as a tow zone, but cars continue to park and block the stop.

Despite the extensive commercial activity on Tremont Street near Huntington Avenue, commercial loading zones are not defined. The lack of loading zones leads truck drivers to double-park, thus blocking a travel lane to unload their products. Car drivers also tend to double-park in order to run quick errands, such as getting a cup of coffee.

The area also seems to present a safety hazard to pedestrians and bus patrons due to the volume of turning movements into and out of the Osco Drug parking lot.

New Dudley Street/Tremont Street/Columbus Avenue

At the intersection of Tremont Street with New Dudley Street and Columbus Avenue the turning radius for left turns southbound from Tremont Street to New Dudley Street is tight and difficult for truck and bus maneuvering. Drivers tend to run the light at the end of the clearance intervals of both the southbound and eastbound Tremont Street approaches. It appears that the traffic demand exceeds the capacity of the intersection, thus delaying vehicles. Long late-afternoon traffic queues on Tremont Street in both directions tend to block the unsignalized intersection to the west at Terrace and Gurney Streets and the Parker Street intersection further west.

The City of Boston employs police officers to direct traffic on Tremont Street to provide gap opportunities for pedestrians and traffic on Terrace Street and Gurney Street. Otherwise, a steady stream of cars both eastbound and westbound would completely block the intersection for the side streets.

Huntington Avenue (Brigham Circle)

Huntington Avenue, which operates with two lanes of traffic in each direction, is congested. Vehicles park on both sides of the street, thus increasing the activity affects traffic flow. Also, a branch of the Green Line runs in the center of the street, amidst mixed traffic. Hence, passengers board and alight from the trolleys in the center median of the street, also adding to impedances to traffic flow.

Eastbound traffic approaching the Tremont Street intersection experiences significant delay in the early and late afternoon. Huntington Avenue west of Tremont Street was reconstructed in 1979-1980 (through an Urban Systems project) to improve safety conditions and the traffic management system.

Parking appears to be unrestricted on both sides of Huntington Avenue from Tremont Street to South Huntington Avenue, with the exception of the bus stops, the trolley stops, and some metered spaces between Tremont Street and Fenwood Street. Spaces are defined by painted lines. West of South Huntington Street, parking is not permitted.

Tremont Street at Huntington Avenue

At the intersection of Tremont Street with Huntington Avenue, left turns and through movements from Tremont Street and Francis Street conflict with each other. The intersection is offset and crosses at an oblique angle. Bus stops on both sides of Huntington Avenue are located on the near side of the intersection in both directions. Bus stops on Tremont Street are located quite close to the intersection. When drivers park cars in the bus stops, bus drivers wait in the travel lanes while passengers board and alight. In the eastbound direction, this results in traffic queuing back into the Huntington Avenue intersection. In terms of the westbound direction, waiting buses cause lost green time in the signal cycle on the Tremont Street approach at Huntington Avenue.

B. Brookline

In Brookline, the bus route has two segments. From Huntington Avenue the buses travel on Washington Street through the intersection of Boylston and High Streets, where Washington Street turns northwest into Brookline Village. The buses then run north on Harvard Street from Washington Street to the Brookline-Brighton border. Overall, the route contains clean, ordered, well-defined roadways, visually pleasing and clearly marked for traffic and parking policies. The streets that comprise the route in Brookline are pedestrian-friendly environments.

Washington Street

Washington Street was recently reconstructed to install an interconnect signal coordination system at three intersections: Brookline Avenue, Boylston and High Streets, and Harvard Street.

Upon entering Brookline on Washington Street westbound, a sign indicates two-hour parking is permitted unless otherwise regulated. The sign is a statement of general policy for the entire town. Parking is not permitted on the Route 9 portion of Washington Street except for a few spaces on the westbound side of the street after Brookline Avenue. Parking is permitted on both sides of the street after it turns right at Boylston Street, where it passes over the "D" branch of the Green Line and enters Brookline Village.

Washington Street/Boylston Street/High Street

At the intersection of Washington Street, Boylston Street, and High Street, the path to access Brookline Village from Boylston Street eastbound is not clearly defined. (For the purposes of the analysis, Washington Street is defined as an east-west arterial. However, since Washington Street has a westbound approach and a southbound approach, it would be more correct to say that Boylston Street is eastbound.) Left turns to Washington Street westbound from Boylston Street eastbound are not permitted. East of the intersection, the signs directing people to Brookline Village are somewhat blocked by other signs. During the midday, traffic queues build on Washington Street eastbound, blocking the intersection of Washington Street and Harvard Street.

Harvard Street

Harvard Street gives an impression of a well-ordered environment, with most of the parking on Harvard Street metered and spaces painted on the parking lane. "No Parking" zones and bus stops are clearly marked. South of Beacon Street at Longwood Avenue, on the southbound side of Harvard Street, there is a clearly marked "No Parking" tow zone.

For the most part, drivers obey the parking restrictions at no-parking zones and bus stops, particularly north of Babcock Street. Some problem areas do exist, however, in the vicinities of Brookline Village (Washington Street) and Coolidge Corner (Beacon Street). In these two areas, existing traffic controls do not accommodate traffic volumes well.

Harvard Street at Washington Street

At the intersection of Harvard Street and Washington Street, the signal favors Washington Street. Heavier traffic volumes occur on Harvard Street. The Harvard Street green phase in the signal cycle appears too short to fully clear the southbound traffic queues.

Between Washington Street and Aspinwall Street, long queues on Harvard Street (both northbound and southbound), coupled with conflicting movements of through traffic and pedestrians, can cause a gridlock situation in the afternoon. This has consequences for drivers at the unsignalized intersection of Pierce Street, since gaps in the Harvard Street through traffic rarely form. In order to manage the children crossing the street from the two nearby schools, the Town stations crossing guards at two other unsignalized intersections on this segment. However, their traffic control efforts, at times, appear to conflict with the signal phasing at Aspinwall. A more effective solution may be to have pretimed pedestrian signals coordinated with Aspinwall at School Street, a signal at Pierce Street, and coordination between the signal system at the School Street intersections with the Washington Street system.

Harvard Street at Aspinwall and School Streets

At Aspinwall and School Streets, Harvard Street has a single travel lane northbound. An outbound bus stop is located on the far side of the intersection. Harvard Street southbound is striped for an inbound bus stop, a single through lane, and a left-turn bay. Buses stopping at the outbound bus stop tend to block the through lane, and also difficult right turning movements from Aspinwall Street. Relocating the stop further north would remove the blockage.

Harvard Street at Longwood Avenue

A key source of delay occurs at the nearby intersection of Harvard Street with Longwood Avenue. Left turns from Harvard Street southbound to Longwood Avenue have minimal opportunities for gaps in the northbound traffic. Illegal parking in a clearly marked tow zone, coupled with parked cars at one or two adjacent legal spaces on the southbound side of Harvard Street, block the southbound through lane while left-turning vehicles queue. The through vehicles then get trapped behind vehicles turning left onto Longwood. Failures on the southbound approach to this intersection cause queues that spill back into Harvard Street at Beacon Street. Although street signs do inform northbound drivers on Harvard Street not to block Longwood Avenue while queuing for the light at Beacon Street, many drivers seem to ignore the sign. Then, once the Harvard Street green phase at Beacon Street comes on, northbound vehicles must wait for the southbound lefts to clear before proceeding to Beacon Street, resulting in lost time at Harvard and Beacon. Cars turning from Longwood Avenue to Harvard Street in either direction lack gap opportunities in the Harvard Street through traffic.

Harvard Street at Beacon Street (Coolidge Corner)

The Green Line passes through the intersection of Harvard Street at Beacon Street in the median of Beacon Street. Left turns are not permitted on any approach, although it is not uncommon to see drivers attempt them. Inbound and outbound station platforms exist on both Beacon Street approaches to the intersection. The platform on the outbound track is too narrow to accommodate the number of passengers expected to wait there for the pedestrian

phase. Boarding and alighting passengers have a tendency to swarm through the intersection upon arrival of the trolleys, regardless of the green phase in operation, blocking traffic on all approaches. Although pedestrians are given ample time in the signal cycle, they tend to ignore the pedestrian phase, thus "stealing" green time from vehicular traffic on Beacon Street and Harvard Street. The signal phase plan includes very long all-red clearance intervals to accommodate pedestrians, but drivers tend to "sneak" the light and get trapped on Harvard Street in the Beacon Street median.

Another problem at this location is north of Beacon Street. The two northbound Harvard Street lanes merge into one lane, causing delays as the cars jockey for position.

C. Brighton

The buses travel on four segments through the neighborhood of Brighton. At the Brookline border, Harvard Street becomes Harvard Avenue. The buses continue on Harvard Avenue to its intersection with Brighton Avenue, where they turn left. From there they continue west to Cambridge Street, where they turn right and proceed east to North Harvard Street. On North Harvard Street, the buses continue north to the Cambridge city line. Inadequate intersection geometry at several location and heavy traffic demand on the minor approaches create a congested environment. These conditions are made worse by limited on-street parking and a prevalent double-parking problem. Significant delay for the buses is not uncommon in this area.

Harvard Avenue

Traffic queues from Commonwealth Avenue and from Brighton Avenue can extend the full length of Harvard Avenue between the two intersections.

Once Harvard Street becomes Harvard Avenue, the parking policy seems undefined. Both sides of the street have a two-hour limit on parking, but spaces are not metered, nor are they painted on the street. The area from Commonwealth Avenue to Cambridge Street is a successful commercial district. Hence, on-street parking is provided on both sides of Harvard Avenue for its entire length. Off-street parking is also available: one small city parking lot exists behind the storefronts adjacent to the Blanchard's property at the corner of Harvard Avenue and Commonwealth Avenue. Access to the lot is gained on the west side of Harvard Avenue, near Commonwealth Avenue, and is shared with the driveway to the Blanchard's parking lot. However, the off-street parking is in short supply, as the lot is always full.

The travel lanes are subject to double parking both by private motorists and by commercial delivery vehicles. Trucks unloading products frequently block the travel lanes, as the on-street parking is generally occupied. This likely points to a shortage of commercial loading zones and a need for more definition and enforcement of the parking policies.

Harvard Avenue at Commonwealth Avenue

The intersection of Commonwealth Avenue and Harvard Avenue is in reality three closely spaced intersections chained together as one. One-way service roads running alongside Commonwealth Avenue exist to provide parking and access to the local residential and commercial properties. Traffic is prohibited from turning left from the frontage roads or

turning right from Commonwealth Avenue, but drivers frequently ignore the signage. The turning restrictions are not well marked. Drivers have been observed to make wide U-turns from a frontage road across Commonwealth Avenue to another frontage road, in the path of an oncoming Green Line trolley.

The "B" branch of the Green Line runs between Commonwealth Avenue westbound and its service road. As the case with Beacon Street, passenger platforms at the Green Line stations are far too narrow: the design of the inbound platform impedes access to the trolleys and imperils waiting passengers who must stand too close to the Commonwealth Avenue travel lanes.

Left turns across the train tracks also pose a frequent problem, as drivers become trapped on the tracks waiting for gaps in the frontage road traffic stream. Drivers also get trapped in the left lanes of Commonwealth Avenue waiting for gaps in the opposing traffic, thus effectively blocking one through lane in each direction.

The signal operates with three phases, including a leading green on Commonwealth Avenue westbound. The service roads run concurrently with Commonwealth Avenue. All movements from Harvard Avenue run with one phase and the vehicles must cross eight travel lanes and the trolley tracks to clear the intersection. Harvard Avenue queues up north of the intersection and blocks the Commonwealth Avenue service road and left turns from Commonwealth Avenue eastbound. Once this happens, Harvard Avenue through traffic is blocked and the intersection fails.

Brighton Avenue

In 1996, the City of Boston initiated the Brighton Avenue Reconstruction Project, which redesigned Brighton Avenue and improved its streetscape. Removal of the old "A" branch Green Line tracks made it possible to construct a raised median and left-turn bays at signalized intersections. The right-of-way allowed for two traffic lanes and a parking lane in each direction. Neck-down curbs at intersections and solid white lines further define the parking lanes, thus clearly separating them from travel lanes. The design also reduces the walk time for pedestrians crossing the intersections. Streetscape redesign and traffic channeling striping contribute to an improved visual environment and a greater sense of safety and security for area residents. Problems identified as part of this inventory are typically related to the level-of-service on the cross streets rather than Brighton Avenue itself.

Harvard Avenue at Brighton Avenue

At Brighton Avenue, significant numbers of vehicles turn left from Harvard Avenue in each direction. These turning movements are in conflict with each other and with through traffic. The signal cycle favors Brighton Avenue and has insufficient green time allocated to Harvard Avenue to accommodate the southbound traffic. The bus stop on Harvard Avenue northbound is located too close to the intersection for the bus to easily navigate the left turn to Brighton Avenue westbound. Although Harvard Street is striped for only one lane, vehicles on both the northbound and southbound approaches tend to form two queues at the intersection. Upon leaving the bus stop, the outbound buses must cut off the vehicles in the

de facto left lanes on Harvard Avenue to make the left turn, or be trapped by the southbound traffic.

Frequently, traffic queues on Harvard Avenue from Brighton Avenue cause the Cambridge Street intersection to fail. Heavy traffic demand on Harvard Avenue to and from Cambridge Street exceeds the capacity of the segment. The heaviest volumes of traffic at the intersection of Cambridge Street and Harvard Avenue are left turns into and right turns out of Harvard Avenue. The signal timing here is designed to accommodate these moves first. Consequently, through traffic on Cambridge Street is delayed by the lack of capacity on Harvard Avenue.

The difficult left-turn maneuver from Harvard Avenue northbound onto Brighton Avenue is further impeded by constrictions to the westbound receiving lane. The design of Brighton Avenue includes a raised median and a neck-down curb at the pedestrian crossing, which limits the turn radius. Vehicles making the left turn routinely cut each other off at this point in the turn, creating further blockage of the intersection during the Harvard Avenue phase.

Brighton Avenue at Cambridge Street

The Brighton Avenue Reconstruction Project also resulted in a redesign of Union Square (the intersection of Brighton Avenue, Cambridge Street, and North Beacon Street). Since then, it has been reported that drivers on Bus Route 66 have had difficulty making the left turn from Cambridge Street southbound to Brighton Avenue eastbound, due to tighter geometry. Also, illegal parking on the departure lanes on North Beacon Street forces two lanes of westbound traffic to squeeze into one lane. Though left turns are prohibited from Cambridge Street northbound to North Beacon Street westbound, drivers do attempt this maneuver.

Harvard Avenue continues north of Brighton Avenue, although the short segment is not part of the bus route. Here, the street drops from four lanes to two lanes (one narrow lane in each direction). The traffic queues on the southbound approach toward Brighton Avenue are lengthy enough to block the intersection at Cambridge Street and Harvard Avenue, resulting in delays to the buses that travel east and west along Cambridge Street. (Further discussion below.)

Cambridge Street

On Cambridge Street northbound, it is unclear where parking is permitted since parking spaces are unmarked. The numerous curb cuts along the segment contribute to an environment that is visually cluttered. Intersection delays affect traffic flow at Union Square, Harvard Avenue, and North Harvard Street.

Cambridge Street at Harvard Avenue

At the intersection of Cambridge Street with Harvard Avenue, delays occur on the left turn from Cambridge Street southbound to Harvard Avenue. The long traffic queues block the intersection, delaying the through traffic, including both the inbound and outbound Route 66 buses.

Cambridge Street at North Harvard Street

At this intersection, accommodating the left turns from Cambridge Street northbound to North Harvard Street appears to be a problem. Heavy traffic volumes on the through movement leave little time to accommodate the demand for the left turns. Since the Route 66 buses turn left here on the outbound trips, transit passengers face excessive delays.

North Harvard Street

North of Western Avenue, drivers park on both sides of North Harvard Street until the intersection with Soldiers Field Road. There appears to be no restriction on parking apart from the bus stops and one no-parking zone located on the approach to Soldiers Field Road within 50 feet of the intersection.

North Harvard Street at Western Avenue

Morning delays occur as traffic approaches Western Avenue on North Harvard Street northbound. The area has many conflicting movements. An unsignalized intersection south of Western Avenue and one at the Dunkin' Donuts property may account for some of the delay. This stretch might benefit from coordinated signal control for the three intersections.

North of Western Avenue and up to the intersection with Soldiers Field Road, cars park on both sides of North Harvard Street. Several closely spaced bus stops on the northbound side are generally blocked by parked cars. Approaching Soldiers Field Road, the "No Parking Zone" is generally blocked by at least six parked cars. There appears to be no restriction on parking, apart from the bus stops and the one no-parking zone.

D. Metropolitan District Commission (MDC)

Two MDC intersections are crossed by Bus Route 66. These intersections, at Soldiers Field Road and Memorial Drive, are located at either end of the Lars Anderson Bridge, which spans the Charles River. In terms of signal timing priority, MDC attempts to maintaining smoother traffic flow on Soldiers Field Road and Memorial Drive direction. At these two intersections, however, the traffic demand exceeds the existing capacity of the intersections. This may simply be a function of the existing signal timing and phase plan, or it may mean that the design of the intersections no longer supports the traffic flow.

North Harvard Street at Soldiers Field Road

At the intersection of North Harvard Street with the ramps for Soldiers Field Road, traffic volume on North Harvard Street northbound is confined to a single lane, due to on-street parking. Often the parking occurs illegally in a no-parking zone near the intersection. Southbound, left turns to Soldiers Field Road are heavy, and queue up across the Lars Anderson Bridge. The southbound approach is striped for two shared left and through lanes, but through vehicles often get trapped behind vehicles turning left. The eastbound and westbound approaches intersect North Harvard Street at separate points 50 feet apart. When queues form for the southbound North Harvard Street left turns, they block the left turns to North Harvard Street from the westbound ramp when the traffic volume cannot be cleared on the North Harvard Street green phase.

John F. Kennedy Street at Memorial Drive

Left-turn traffic volumes are heavy on every approach at John F. Kennedy Street and Memorial Drive. The signal has a four-phase operation, with a short leading green for northbound left turns, and an exclusive pre-timed pedestrian phase. Traffic turning left on all four approaches tends to get trapped in the intersection by the through traffic on each approach, resulting in extensive delay. In addition, through traffic gets trapped in the lanes where the left-turning vehicles wait for gaps in the opposing traffic.

E. Cambridge

The bus route travels on John F. Kennedy (JFK) Street from Memorial Drive up to Eliot Street, where the buses then turn left. The outbound trips go through the Harvard Square loop, returning to John F. Kennedy on Eliot Street. In general, problems encountered in Cambridge stem from traffic delays due to double-parking and heavy pedestrian volumes further west on John F. Kennedy. Traffic can spill back as far as Memorial Drive, at times.

On John F. Kennedy Street parking is not permitted between Memorial Drive and Eliot Street. John F. Kennedy Street from Mount Auburn Street to Massachusetts Avenue has metered parking on both sides of the street. The street is fronted by a variety of commercial and retail properties. Double-parking is a frequent occurrence as trucks unload products for these businesses, causing significant traffic delay. Between Eliot and Brattle Street, metered parking on both sides of John F. Kennedy is restricted to one hour; spaces are clearly painted on the road. Enforcement of parking policy in Cambridge is generally strict.

Heavy northbound traffic volumes pass through toward Harvard Square, frequently backing up from Massachusetts Avenue clear through to North Harvard Street at Soldiers Field Road. These lengthy queues are exacerbated by poor accommodation of left-turning vehicles at John F. Kennedy Street and Memorial Drive.

Harvard Square acts as a choking point for the JFK Street traffic. Delays can be attributed to heavy volumes of pedestrians passing through the square to and from Harvard University, the Red Line train station, and the transit busway. Harvard Square is heavily pedestrian oriented, and pedestrians often cross John F. Kennedy at Brattle Street against the flow of traffic and the signal phase. Also, a difficult and potentially hazardous traffic merge at the intersection of John F. Kennedy Street and Massachusetts Avenue also contributes to the delay.

John F. Kennedy Street at Mount Auburn Street

The pedestrian phasing at Mount Auburn Street is concurrent with the green phases. Frequent conflicts occur between bicycles going straight on John F. Kennedy and vehicles turning right to Mount Auburn Street. The delay on this segment is significant, causing queues that can extend as far back as Lars Anderson Bridge.

F. Summary of Route Reconnaissance

Overall, the entire corridor experiences some degree of congestion. Most of the signalized intersections seem to operate at a poor level-of-service at some point during the day. Failures at downstream signals often compound the problems at nearby upstream signals. In some cases, the problems appear to stem from heavy traffic volumes. In other cases, the signal timings and phase plans do not appear well adjusted to the traffic volumes by approach. Furthermore, parked cars are prevalent on both sides of the street throughout most of the bus route, including in designated bus stop zones. Several segments of the route are crowded and cluttered, which may confuse drivers about parking restrictions. Particularly in these areas, double-parking in the travel lanes is a recurring problem. CTPS identified two commercial loading zones along the route, neither of which was located where the double parking occurs.

Appendix D:

Travel Time Data Collection (Technical Memorandum)

MEMORANDUM

TO: Mark Berger, MassHighway - BTP&D
David Carney, MBTA Service Planning

November 19, 1998

FROM: Amanda Amory

RE: GPS Travel Time Data Collection and Identification of Priority Locations for Intersection Level of Service Analysis (Bus Route 66 Study)

This memo completes Subtask 2.1 of the work program for the MBTA Bus Route 66 Arterial Improvement Study. It documents the findings of a recent travel time study which identified areas along the bus route where travel speeds are low and vehicle stopped-delay is high. If improvements to traffic flow can be made at these areas, then schedule adherence problems facing the bus drivers can be reduced or eliminated, resulting in better service coverage on the route. The locations identified were deemed high priority for collection of turning movement data and analysis of highway capacity, to identify the roots of the delay problems. The travel time study is a preliminary measure of the existing arterial level of service for Bus Route 66, as defined in the 1994 Highway Capacity Manual. The highway capacity analysis recommended for the identified locations will provide a final assessment of existing level of service and will serve as the base condition for testing improvement strategies.

Study Area

Bus Route 66 travels over a series of major and minor arterials with 40 intersections controlled by traffic signals. Pedestrian conflicts and lane obstructions resulting from taxi stands, buses, trucks, and parking vehicles are typical phenomena along the route. Listed below are the roads over which the Route 66 buses travel, in sequence from Dudley Station in Roxbury to Harvard Square in Cambridge. They are classified as minor arterials of urban design, or Class III. This design consists of densely spaced commercial roadside development, permitted parking, few separate left-turn lanes, pedestrian activity, 6 to 12 signals per mile, and speed limits of 25 to 35 miles per hour. A map of the study area is presented in Figure 1.

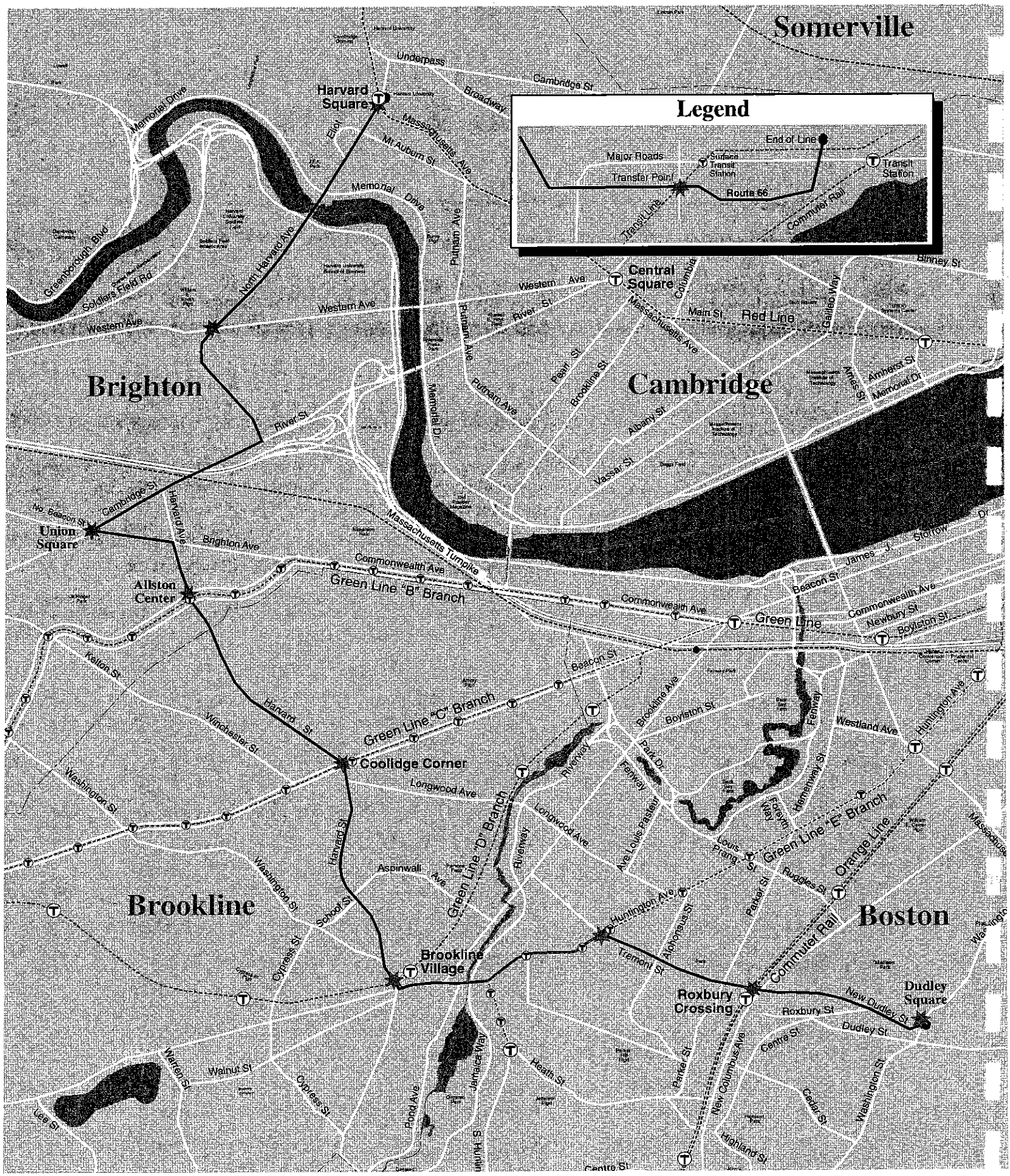
Roxbury

- Dudley Street/New Dudley Street from Warren Street to Tremont Street.
- Tremont Street from New Dudley Street to Huntington Avenue.
- Huntington Avenue from Tremont Street to the Boston/Brookline town line.

Brookline

- Washington Street from the Brookline town line, through its intersection with Boylston and High Streets, to Harvard Street in Brookline Village.

Figure 1
Study Area for MBTA Bus Route 66
Arterial Improvement Study



- Harvard Street from Washington Street to the Boston/Brookline town line.

Brighton

- Harvard Avenue from the Boston/Brookline town line to Brighton Avenue.
- Brighton Avenue from Harvard Avenue to Cambridge Street at Union Square.
- Cambridge Street from Brighton Avenue to North Harvard Street.
- North Harvard Street from Cambridge Street to the Boston/Cambridge city line at the Larz Anderson Bridge.

Cambridge

- JFK Boulevard (formerly referred to as Boylston Street) from the Boston/Cambridge city line at the Larz Anderson Bridge to Harvard Square.

Data Collection

CTPS conducted travel time runs of the Bus Route 66 corridor during the months of April, May, and June of 1998 using field data obtained from the Global Positioning System (GPS). The GPS offers an accurate method for collecting data on vehicle position second-by-second. Prior to the application of GPS for travel time studies, travel times were taken manually, by noting the time and the spot speed of a vehicle as it traveled along a segment of an arterial. The speed observation was the average running speed, which had to be adjusted for stopped delay at signals and along the segment. Data had to be collected for each segment at separate times, and proved to be quite time consuming. The GPS automates the process, making it possible to obtain both running speed and stopped delay continuously, yielding the average travel speed.

The study covered three time periods: AM peak, from 7:00 AM to 9:00 AM; midday, from 12:00 PM to 2:00 PM; and PM peak, from 4:00 PM to 6:00 PM. The midday period was selected based on the peak midday bus ridership period between 9:00 AM and 4:00 PM. Based on the recommendations of the Highway Capacity Manual,[1] a total of 60 trips were run, 10 in each direction in each time period, to obtain a range of travel times for each segment along the route. Vehicle travel time was measured at one-second intervals over a set of segments. Drivers used laptop computers outfitted with GPS units to record latitude-longitude coordinate points for each second of the travel time run. The distance between these points varied according to the speed of the vehicle. Segments were defined as the one-directional distance from one signalized intersection to the next.

Methodology

The Highway Capacity Manual describes methodologies for assessing delay at intersections and urban arterial level of service. These methodologies were used to evaluate the travel time data and determine the locations of traffic congestion. Arterial level of service is based on average through-vehicle travel speed for the arterial. Intersection level of service is based on the average stopped delay per vehicle. The GPS vehicle position data was processed through a geographic information system to convert it to travel time, travel speed, and stopped delay per segment per trip. From there, the segment data was averaged across all trips in each time period, assigned to categories of level of service for average travel speed and segment delay, and mapped. The

[1] Highway Capacity Manual Special Report 209 (updated October 1994), page 11-35; "Six to twelve runs for each traffic-volume condition may be adequate." (See HRB Proc. 1952, pp. 864-866.)

average speed was computed from the elapsed distance between each of the coordinate points recorded each second along the segment, and the elapsed time between the endpoint of the prior segment and the endpoint of the current segment. Stopped delay consisted of the duration of periods when the vehicle traveled at less than 5 miles per hour, with a minimum limit of three consecutive seconds at that travel speed.

For Class III arterials, the Arterial level-of-service criteria are divided into six categories ranging from A to F and highest speeds to lowest speeds, as shown in Table 1. The arterial is divided into segments, defined as the one-directional distance from one signalized intersection to the next. Average travel speed is obtained for each segment, and is then compared to the criteria for arterial level of service.

Table 1 Class III Arterial Levels of Service

Level of Service	Average Travel Speed (MPH)
A	≥ 25
B	≥ 19
C	≥ 13
D	≥ 9
E	≥ 7
F	< 7

For signalized intersections, level-of-service is also divided into six categories ranging from A to F. Each category is assigned a range of delay expressed in seconds, as shown in Table 2. These levels of service serve as a measure of driver discomfort and lost travel time. Substandard operation of traffic signals can result in through-movement delays exceeding one minute. If there are many signals with substandard operations along an arterial, the average delays at the intersections would have a cumulative adverse affect on traffic operations. Furthermore, delay to through traffic at intersections must be balanced against the delay facing drivers on the cross streets.

Table 2 Level-of-Service Criteria for Signalized Intersections

Level of Service	Stopped Delay per Vehicle (sec)
A	≤ 5
B	> 5 and ≤ 15
C	> 15 and ≤ 25
D	> 25 and ≤ 40
E	> 40 and ≤ 60
F	> 60

The LOS assessment of average travel speed by segment can appear better on paper than what a driver may experience in traffic. Variation in segment lengths affects the calculation of average speed. Shorter segments will have lower travel speeds, in general, as drivers prepare to stop at signals or lack sufficient time to accelerate to free-flow speed. Longer segments tend to have more favorable average speeds since periods of delay are averaged across longer distances of higher average speed, masking the delay.

Stopped delays can occur anywhere along a segment, resulting from a variety of causes, such as double-parked cars and commercial vehicles, high pedestrian activity in commercial areas or school zones, and large volumes of vehicles making left turns without protected signal phases or exclusive lanes. These temporary friction factors can affect drivers' perceptions of the road. Though they occur frequently, not all of the travel time trips experienced these delays. Nor did the drivers encounter red lights at every signal. To adjust for potential bias in the average speed assessment, CTPS computed the average stopped delay from the GPS data. Since the segments defined in this study are short, extending from signal to signal, the bulk of the delay was generally assumed to occur at the intersections. For the purposes of the travel time study, stopped delays were accumulated from the entire length of each segment, and assigned to the downstream intersection. In reality, the intersection level of service might be better than is stated in this document. The priority locations for further study are thus identified through a combination of the two measures.

One advantage to the use of the GPS for field collection of travel time data is that the data can then be mapped, using a geographic information system, to provide a visual reference of the locations of both slow arterial segments and failing intersections. Average travel speed and average stopped delay by segment can be color-coded by level-of-service ranges, then mapped in bands that follow the path of the arterial in question, as illustrated in Figures 2 through 7. Note that the segment delay level-of-service maps (Figures 5, 6, and 7) are significantly different from the speed-based level of service maps (Figures 2, 3, and 4). In part, this is because intermittent midblock delays have been assigned to the intersection at the end of the segment. In part, it is because longer segments tend to have higher average speeds than shorter segments. While stopped delay at an intersection may indicate a poor level of service, a relatively high average speed may prevail over most of the segment. The delay, while severe, might not pull the average speed down far enough to appear as critical in Figures 2, 3, and 4. However, segments where the average speed is LOS E or F on the map definitely indicate a problem on the segment.

Average Speed and Level of Service

For the inbound and the outbound routes, respectively, Tables 3 and 4 list the average travel speed and the arterial level of service by segment for each time period. Segments where the arterial level of service was E or F (average speeds less than 9 or 7 miles per hour, respectively) are considered to be critical segments (and are shown in **bold face**). The average travel speeds by segment were compared to the level-of-service criteria and mapped, as illustrated in Figures 2, 3, and 4.

Overall, the route operated at LOS D throughout the day in each direction. During the AM peak period, four segments operated at LOS E, two inbound and two outbound. During the midday and PM peak, the problems increased. Some segments operated at LOS F, and the number of LOS E segments also increased.

Inbound, from Cambridge to Roxbury, the critical segments are:

- Harvard Avenue from Brighton Avenue to Commonwealth Avenue, Midday & PM peaks.
- Harvard Street from Babcock Street to Beacon Street, AM & PM peaks.
- Harvard Street from Aspinwall/School Streets to Washington Street, Midday & PM peaks.
- Washington Street from Harvard Street to Boylston/High Streets (Route 9), AM & Midday peaks.
- Washington Street from Boylston/High Streets (Route 9) to Brookline Avenue, PM peak.

- Tremont Street from Parker Street to New Dudley Street/Columbus Avenue, Midday & PM peaks.
- New Dudley Street from Shawmut Avenue to Washington Street, Midday and PM peaks.
- Dudley Street from Washington Street to Warren Street, PM Peak.

Outbound, from Roxbury to Cambridge, the critical segments (those with arterial LOS E or F) are:

- Tremont Street from Saint Alphonsus Street to Huntington Avenue, AM & PM peaks.
- Harvard Avenue from Commonwealth Avenue to Brighton Avenue, Midday & PM peaks.
- Cambridge Street from Lincoln Street to North Harvard Street, AM & PM Peaks.
- JFK Boulevard (formerly Boylston Street) from Memorial Drive to Mount Auburn Street, Midday.

Average Segment Delay and Level of Service

For every segment, a measure of delay was calculated in the GIS. Delay is defined as the number of seconds a vehicle is traveling at less than 5 miles per hour on a segment, as long as speeds have been lower than 5 mph for 3 consecutive seconds. The value of 5 miles per hour was selected to allow for natural drift in the GPS tracking. Delay was calculated for every run on every segment, and an average segment delay was calculated for each time period.

The delay measures on each segment were compared to intersection levels of service as defined in Chapter 9 of the Highway Capacity Manual. The average stopped delay is reported here by the segment on which it occurs, as listed in Tables 5 and 6 and illustrated in Figures 5 through 7. The segment delay is an indicator that the downstream intersection may have a problem. Segments where the average stopped delay was equivalent to intersection level of service E or F (more than 40 or 60 seconds of delay, respectively) were considered to be critical segments. CTPS will analyze the downstream intersections for each critical segment.

Based on the critical segments, eighteen intersections were identified as having potential level-of-service problems for through-vehicles, as listed below. The average segment delay was compared to the route and mapped, as illustrated in Figures 5, 6, and 7. From the segment delay results, the critical intersections are as follows:

Roxbury

- Tremont Street, New Dudley Street, and Columbus Avenue inbound (AM, Mid) and outbound (Mid and PM).
- Tremont Street at Huntington Avenue inbound and outbound (AM, Mid, PM).

Brookline

- Washington Street at Brookline Avenue inbound (PM).
- Washington Street at Boylston & High Streets inbound (AM).
- Harvard Street at Washington Street inbound (Mid, PM).
- Harvard Street at School Street and Aspinwall Street outbound (AM, Mid).
- Harvard Street at Beacon Street inbound (AM) and outbound (AM, PM).
- Harvard Street at Stedman Street inbound (PM).

Table 3

Bus Route 66 Improvement Study

Preliminary Arterial Level of Service for Bus Route 66 Based On Average Speed, Inbound

Based on GPS Field Observations Spring 1998

Segment Endpoints		Inbound Segment	Length (Miles)	AM Peak Avg Speed	AM Peak LOS	Midday Peak Avg Speed	Midday Peak LOS	PM Peak Avg Speed	PM Peak LOS
Cambridge									
JFK Boulevard (Formerly Boylston Street)									
1	2	Garden Street to Brattle Street	0.23	13.4	C	10.3	D	11.6	D
Eliot Street									
2	3	Brattle Street to JFK Street	0.16	9.6	D	12.8	D	11.6	D
JFK Boulevard (Formerly Boylston Street)									
3	4	JFK Street to Memorial Drive	0.15	9.4	D	13.4	C	10.4	D
Larz Anderson Bridge									
4	5	Memorial Drive to Soldiers Field Road	0.14	20.7	B	21.5	B	20.2	B
Brighton									
North Harvard Street									
5	6	Soldiers Field Road to Western Ave	0.47	17.9	C	14.5	C	18.1	C
6	7	Western Ave to Cambridge Street	0.49	14.7	C	17.8	C	14.6	C
Cambridge Street									
7	8	North Harvard Street to Lincoln Street	0.11	21.8	B	21.4	B	23.1	B
8	9	Lincoln Street to Harvard Ave	0.28	21	B	30	A	21.6	B
9	10	Harvard Ave to Brighton Ave & Beacon Street	0.29	14.7	C	12	D	16.3	C
Brighton Ave									
10	11	Cambridge Street & North Beacon Street to Allston Street	0.16	22.8	B	19.9	B	20.2	B
11	12	Allston Street to Harvard Ave	0.15	17.5	C	13.9	C	11.3	D
Harvard Ave									
12	13	Brighton Ave to Commonwealth Ave	0.19	12.5	D	7.8	E	6.5	F
Brookline									
Harvard Street									
13	14	Commonwealth Ave to Verndale Street	0.16	21.8	B	19.3	B	22	B
14	15	Verndale Street to Stedman Street	0.40	19.9	B	18.3	C	14.8	C
15	16	Stedman St to Babcock St	0.12	17.9	C	11.4	D	11.8	D
16	17	Babcock Street to Beacon Street	0.14	7.7	E	9.4	D	8.4	E
17	18	Beacon Street to Vernon Street	0.28	21.1	B	16.9	C	18.2	C
18	19	Vernon Street to Aspinwall &School Street	0.22	14.7	C	17.7	C	14.9	C
19	20	Aspinwall &School Streets to Washington Street	0.22	13.6	C	8.5	E	6	F
Washington Street									
20	21	Harvard Street to Rte 9 (Boylston & High Streets)	0.14	7.3	E	7	E	9.6	D
21	22	Rte 9 (Boylston & High Streets) to Brookline Ave	0.21	17.6	C	13.1	C	8	E
Roxbury									
22	23	Brookline Ave to South Huntington Street	0.11	13.9	C	21.5	B	9.8	D
Huntington Ave									
23	24	South Huntington Street to Parker Hill	0.14	11.8	D	19.3	B	15.1	C
24	25	Parker Hill to Tremont Street	0.29	13.9	C	12.7	D	10.2	D
Tremont Street									
25	26	Tremont Street to St. Alphonsus Street	0.19	14.3	C	13.9	C	10.4	D
26	27	St Alphonsus Street to Parker Street	0.24	18.4	C	20.9	B	13.4	C
27	28	Parker Street to New Dudley Street	0.14	11	D	8.5	E	6.7	F
New Dudley Street									
28	29	New Dudley Street to Madison Park High School X-walk	0.28	21.7	B	22.6	B	26.2	A
29	30	Madison Park High School X-walk to Shawmut Ave	0.23	19.8	B	17.2	C	18.5	C
30	31	Shawmut Ave to Washington Street	0.04	16.5	C	7.3	E	7.8	E
31	32	Washington Street to Warren Street	0.10	9.3	D	10.3	D	8.6	E
Overall Arterial			6.47	12.4	D	12.7	D	10.9	D

Table 4

Bus Route 66 Improvement Study

Preliminary Arterial Level of Service for Bus Route 66 Based on Average Speed, Outbound

Based on GPS Field Observations Spring 1998

Segment Endpoints		Outbound Segment	Length (Miles)	AM Peak Avg Speed	AM Peak LOS	Midday Peak Avg Speed	Midday Peak LOS	PM Peak Avg Speed	PM Peak LOS
Roxbury									
Dudley Street									
1	2	Warren Street to Washington Street (surrogate for Dudley	0.10	17.7	C	18.3	C	15.4	C
2	3	Washington Street to Shawmut Ave	0.03	25	A	29.7	A	28.1	A
New Dudley Street									
3	4	Shawmut Ave to Madison Park High School X-walk	0.23	22.5	B	31.1	A	32.1	A
4	5	Madison Park High School X-Walk to Columbus Ave	0.27	13.9	C	13.5	C	14.3	C
Tremont Street									
5	6	Columbus Ave to Parker St	0.13	17	C	25.8	A	17.3	C
6	7	Parker Street to St Alphonsus Street	0.22	12.2	D	17	C	15.8	C
7	8	St Alphonsus Street to Huntington Ave (Rte 9)	0.20	8.3	E	10.3	D	7	E
Huntington Ave									
8	9	Huntington Ave (Rte 9) to Parker Hill Street	0.28	15.8	C	20.3	B	14.7	C
9	10	Parker Hill Street to South Huntington Ave	0.15	16.8	C	15.6	C	15.4	C
Brookline									
Washington Street									
10	11	South Huntington Ave to Brookline Ave	0.10	16.8	C	16.8	C	14.8	C
11	12	Brookline Ave to Boylston St/High Street (Rte 9)	0.20	11.3	D	12	D	12.1	D
12	13	Boylston St/High Street (Rte 9) to Harvard Street	0.13	13.5	C	13.5	C	13.5	C
Harvard Street									
13	14	Washington Street to School Street & Aspinwall Street	0.23	13.5	C	11.2	D	12	D
14	15	School Street & Aspinwall Street to Vernon Street	0.21	23.8	B	19.5	B	18.8	C
15	16	Vernon Street to Beacon Street	0.26	12.4	D	11.7	D	11.1	D
16	17	Beacon Street to Babcock Street	0.14	16.5	C	13.6	C	13.4	C
17	18	Babcock Street to Stedman Street	0.10	20.5	B	18.3	C	17.5	C
18	19	Stedman Street to Verndale Street	0.40	22.1	B	20.1	B	19.8	B
19	20	Verndale Street to Commonwealth Ave	0.20	12.6	D	10.5	D	10.3	D
Brighton									
Harvard Ave									
20	21	Commonwealth Ave to Brighton Ave	0.14	10.4	D	5.8	F	8.9	E
Brighton Ave									
21	22	Harvard Ave to Allston Street	0.15	15.8	C	23.6	B	17.5	C
22	23	Allston Street to Cambridge Street & North Beacon Street	0.15	11.3	D	22.2	B	17.5	C
Cambridge Street									
23	24	Brighton Ave & North Beacon Street to Harvard Ave	0.29	10.5	D	20.7	B	11.2	D
24	25	Harvard Ave to Lincoln Street	0.26	28.3	A	26.2	A	23.3	B
25	26	Lincoln Street to North Harvard Street	0.11	7.2	E	9.2	D	6.3	F
North Harvard Street									
26	27	Cambridge Street to Western Ave	0.47	15	C	19.4	B	17.3	C
27	28	Western Ave to Soldiers Field Rd	0.46	17	C	21.1	B	14.2	C
Cambridge									
Larz Anderson Bridge									
28	29	Soldiers Field Road to Memorial Drive	0.14	12.8	D	13.5	C	11.3	D
JFK Boulevard (formerly Boylston Street)									
29	30	Memorial Drive to Mount Auburn Street	0.23	12.1	D	8.9	E	11.4	D
30	31	Mount Auburn Street to Mass. Ave.	0.09	11.6	D	13.4	C	12.7	D
31	32	Mass. Ave to Garden Street	0.14	9.9	D	15.3	C	10.9	D
Overall Arterial			6.21	11.9	D	12.8	D	11.6	D

FIGURE 2

Boston MPO Region Congestion Management System

Bus Route #66 Corridor 1998 AM Peak Period Speed –Based Level of Service

AM Peak Period
Level of Service

- Level of Service F (Less than 7 MPH)
- Level of Service E (From 7 to 8.9 MPH)
- Level of Service D (From 9 to 12.9 MPH)
- Level of Service C (From 13 to 18.9 MPH)
- Level of Service B (From 19 to 24.9 MPH)
- Level of Service A (From 25 to 35 MPH)

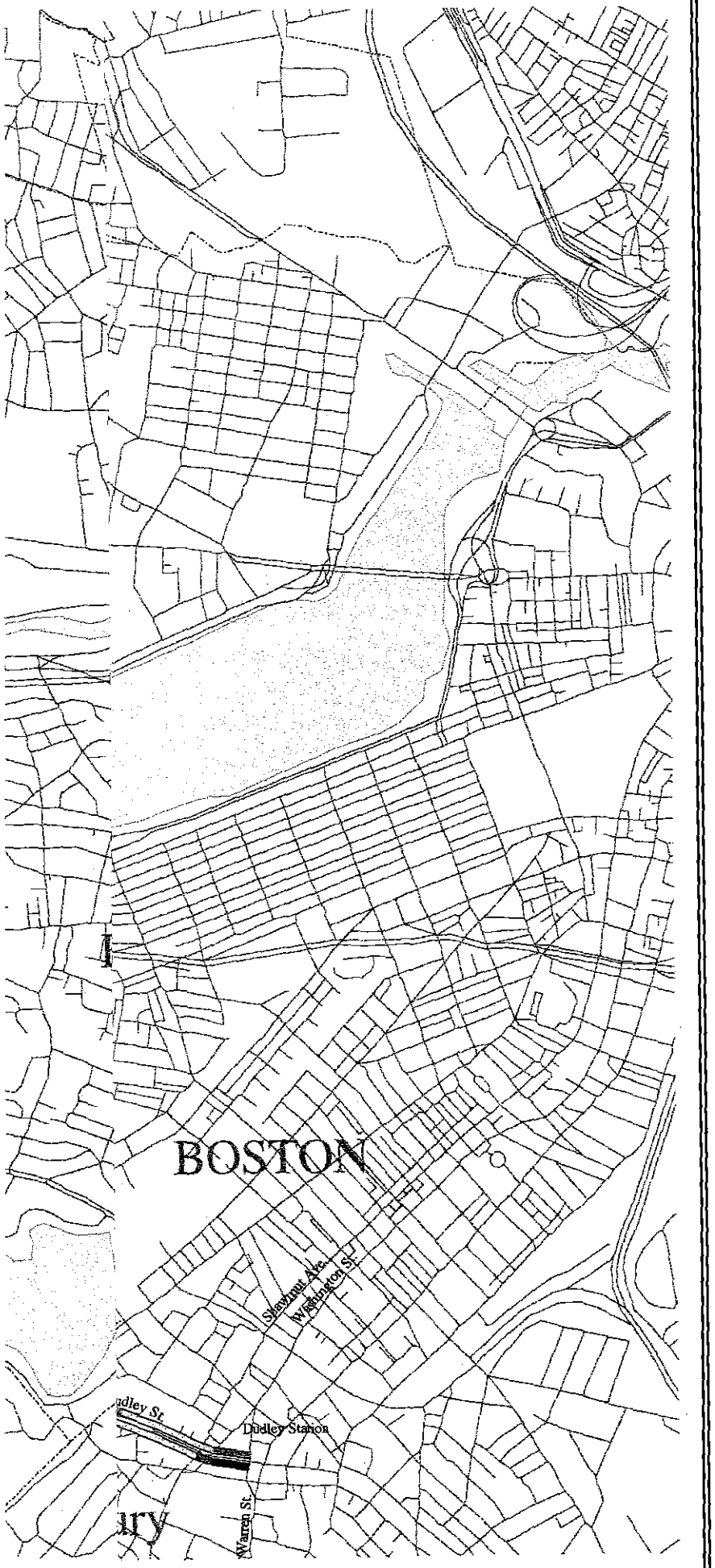


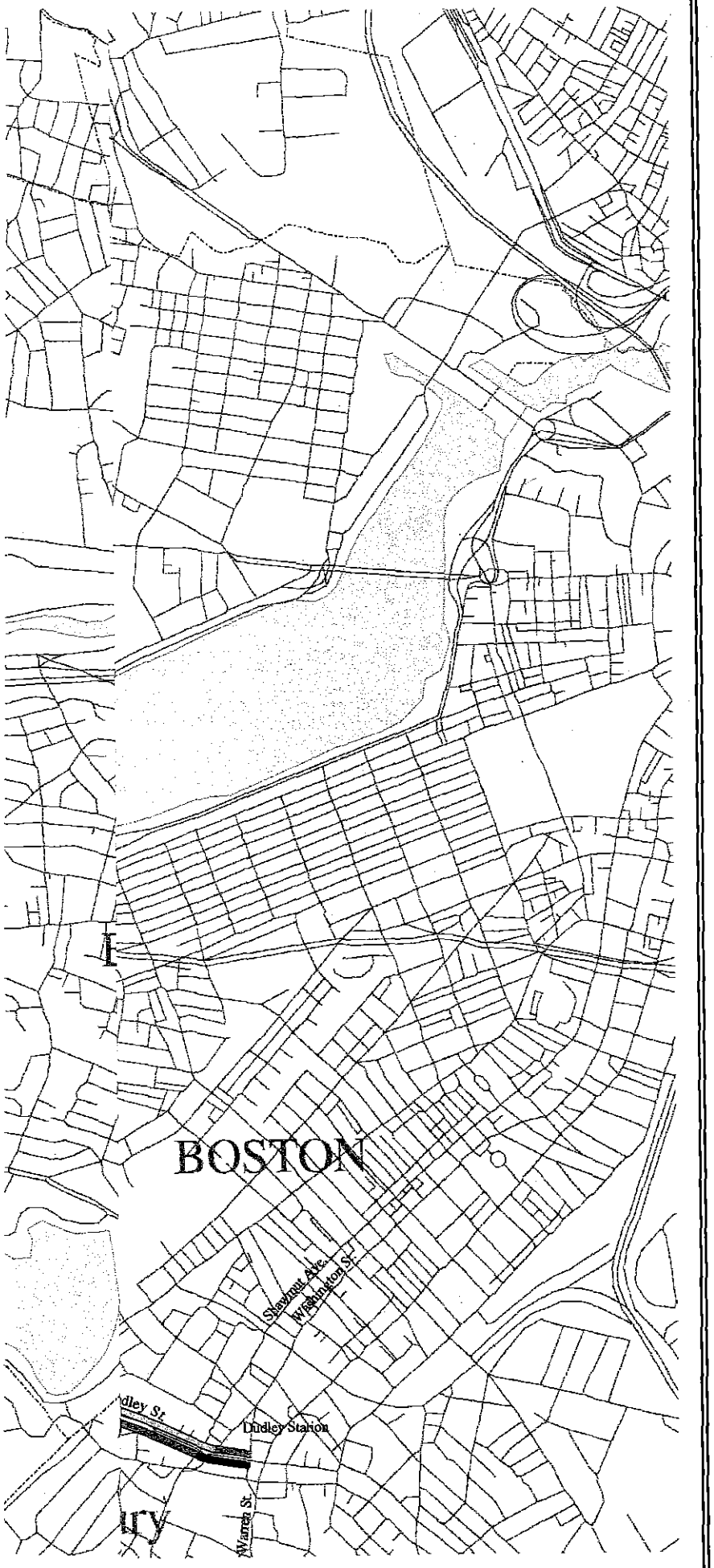
FIGURE 3

Boston MPO Region Congestion Management System

Bus Route #66 Corridor 1998 Midday Period Speed –Based Level of Service

Midday Period
Level of Service

- Level of Service F (Less than 7 MPH)
- Level of Service E (From 7 to 8.9 MPH)
- Level of Service D (From 9 to 12.9 MPH)
- Level of Service C (From 13 to 18.9 MPH)
- Level of Service B (From 19 to 24.9 MPH)
- Level of Service A (From 25 to 35 MPH)



Brighton

- Harvard Street at Commonwealth Avenue inbound and outbound (Mid, PM).
- Harvard Avenue at Brighton Avenue outbound (AM, Mid, PM).
- Cambridge Street at Brighton Avenue inbound (Mid).
- Cambridge Street at Harvard Avenue outbound (AM, PM).
- Cambridge Street at North Harvard Street inbound and outbound (AM, PM).
- North Harvard Street at Western Avenue inbound and outbound (AM, Mid, PM).
- North Harvard Street at Soldiers Field Road outbound (AM, PM).

Cambridge

- JFK Boulevard at Memorial Drive inbound (AM).
- Eliot Street at JFK Boulevard inbound (AM).
- JFK Boulevard at Mount Auburn Street inbound and outbound (AM, Mid).

In addition to the intersections listed above, field observation showed a problem at the intersection of Warren Street at Dudley Street in Roxbury. This intersection was missed in the travel time runs because of the path that the data collectors took while running the route. The data shows, however, that average speeds on inbound runs are critical, indicating a problem on the Dudley Street eastbound approach. The intersection of Warren and Dudley Street should be added to the list of locations for further analysis.

To illustrate the problem locations more clearly, and visually summarize the information in the two lists above, two more maps were created (see Figures 8 and 9). The representations split the data into inbound and outbound lists. Segments and intersections are shown together on each map. The maps illustrate which segments and intersections at what times of day are problematic. In addition, the information is condensed into tables 8 and 9, which list the critical locations in sequential order by time period, for each direction.

Recommendations

The critical segments from the speed-based LOS analysis, and the signalized intersections identified in the delay analysis will be evaluated with the Highway Capacity software. While the travel time study was useful at showing the locations of significant problems on the major streets, problems on the cross streets were not obtained. Any improvement alternatives to be tested will have to be weighed against cross street delays. Based on turning movement volumes, existing signal timings, and geometrics, the signalized intersections will be investigated first, to determine if signal retiming and coordination, changes to lane configurations, and/or changes in bus stop locations and parking can improve traffic flow. Additional investigations will target segments with poor level of service, focusing on midsegment problems such as unsignalized intersections, double parking, and location of loading zones (or the lack thereof).

The travel time study and the highway capacity analysis will be presented to the traffic engineers from each town to obtain their comments. From there, we will test strategies to develop an improvement plan.

Table 5

Bus Route 66 Improvement Study

Preliminary Arterial Level of Service for Bus Route 66 Based On Segment Delay, Inbound

Based on GPS Field Observations Spring 1998

Segment Endpoints		Inbound Segment	AM Peak Avg Delay	AM Peak LOS	Midday Peak Avg Delay	Midday Peak LOS	PM Peak Avg Delay	PM Peak LOS
Cambridge								
JFK Boulevard (Formerly Boylston Street)								
1	2	Garden Street to Brattle Street	00:17	C	00:28	D	00:27	D
Eliot Street								
2	3	Brattle Street to JFK Street	00:48	E	00:28	D	00:32	D
JFK Boulevard (Formerly Boylston Street)								
3	4	JFK Street to Memorial Drive	01:09	F	00:16	C	00:33	D
Larz Anderson Bridge								
4	5	Memorial Drive to Soldiers Field Road	00:23	C	00:02	A	00:01	A
Brighton								
North Harvard Street								
5	6	Soldiers Field Road to Western Ave	00:31	D	00:53	E	00:41	E
6	7	Western Ave to Cambridge Street	00:53	E	00:34	D	01:01	F
Cambridge Street								
7	8	North Harvard Street to Lincoln Street	00:01	A	00:02	A	00:01	A
8	9	Lincoln Street to Harvard Ave	00:08	B	00:00	A	00:08	B
9	10	Harvard Ave to Brighton Ave & Beacon Street	00:27	D	00:50	E	00:19	C
Brighton Ave								
10	11	Cambridge Street & North Beacon Street to Allston Street	00:00	A	00:04	A	00:23	C
11	12	Allston Street to Harvard Ave	00:16	C	00:15	B	00:30	D
Harvard Ave								
12	13	Brighton Ave to Commonwealth Ave	00:28	D	01:04	F	01:13	F
Brookline								
Harvard Street								
13	14	Commonwealth Ave to Verndale Street	00:01	A	00:03	A	00:03	A
14	15	Verndale Street to Stedman Street	00:14	B	00:17	C	00:40	E
15	16	Stedman St to Babcock St	00:11	B	00:11	B	00:17	C
16	17	Babcock Street to Beacon Street	00:45	E	00:23	C	00:28	D
17	18	Beacon Street to Vernon Street	00:02	A	00:23	C	00:04	A
18	19	Vernon Street to Aspinwall &School Street	00:24	C	00:14	B	00:31	D
19	20	Aspinwall &School Streets to Washington Street	00:32	D	01:03	F	01:48	F
Washington Street								
20	21	Harvard Street to Rte 9 (Boylston & High Streets)	00:41	E	00:30	D	00:26	D
21	22	Rte 9 (Boylston & High Streets) to Brookline Ave	00:23	C	00:17	C	00:40	E
Roxbury								
22	23	Brookline Ave to South Huntington Street	00:40	D	00:03	A	00:40	E
Huntington Ave								
23	24	South Huntington Street to Parker Hill	00:19	C	00:02	A	00:12	B
24	25	Parker Hill to Tremont Street	00:22	C	00:55	E	01:10	F
Tremont Street								
25	26	Tremont Street to St. Alphonsus Street	00:15	B	00:17	C	00:32	D
26	27	St Alphonsus Street to Parker Street	00:08	B	00:02	A	00:29	D
27	28	Parker Street to New Dudley Street	00:55	E	00:55	E	00:37	D
New Dudley Street								
28	29	New Dudley Street to Madison Park High School X-walk	00:02	A	00:05	A	00:00	A
29	30	Madison Park High School X-walk to Shawmut Ave	00:14	B	00:20	C	00:28	D
30	31	Shawmut Ave to Washington Street	00:04	A	00:13	B	00:15	B
31	32	Washington Street to Warren Street	00:38	D	00:10	B	00:23	C
Average Segment Delay			00:24	C	00:23	C	00:31	D
Cumulative Average Arterial Delay			12:10		11:21		15:33	

Table 6

Bus Route 66 Improvement Study

Preliminary Arterial Level of Service for Bus Route 66 Based on Segment Delay, Outbound

Based on GPS Field Observations Spring 1998

Segment Endpoints		Outbound Segment	AM Peak Avg Delay	AM Peak LOS	Midday Peak Avg Delay	Midday Peak LOS	PM Peak Avg Delay	PM Peak LOS
Roxbury								
Dudley Street								
1	2	Warren Street to Washington Street (surrogate for Dudley S	00:01	A	00:03	A	00:09	B
2	3	Washington Street to Shawmut Ave	00:00	A	00:00	A	00:00	A
New Dudley Street								
3	4	Shawmut Ave to Madison Park High School X-walk	00:06	B	00:00	A	00:00	A
4	5	Madison Park High School X-Walk to Columbus Ave	00:34	D	00:53	**E**	00:45	**E**
Tremont Street								
5	6	Columbus Ave to Parker St	00:09	B	00:00	A	00:01	A
6	7	Parker Street to St Alphonsus Street	00:39	D	00:14	B	00:16	C
7	8	St Alphonsus Street to Huntington Ave (Rte 9)	01:12	**F**	01:04	**F**	01:06	**F**
Huntington Ave								
8	9	Huntington Ave (Rte 9) to Parker Hill Street	00:22	C	00:11	B	00:22	C
9	10	Parker Hill Street to South Huntington Ave	00:30	D	00:20	C	00:15	B
Brookline								
Washington Street								
10	11	South Huntington Ave to Brookline Ave	00:05	A	00:10	B	00:33	D
11	12	Brookline Ave to Boylston St/High Street (Rte 9)	00:23	C	00:30	D	00:18	C
12	13	Boylston St/High Street (Rte 9) to Harvard Street	00:07	B	00:08	B	00:11	B
Harvard Street								
13	14	Washington Street to School Street & Aspinwall Street	00:45	**E**	00:41	**E**	00:38	D
14	15	School Street & Aspinwall Street to Vernon Street	00:02	A	00:08	B	00:10	B
15	16	Vernon Street to Beacon Street	00:41	**E**	00:37	D	00:55	**E**
16	17	Beacon Street to Babcock Street	00:07	B	00:05	A	00:08	B
17	18	Babcock Street to Stedman Street	00:00	A	00:04	A	00:03	A
18	19	Stedman Street to Verndale Street	00:09	B	00:08	B	00:17	C
19	20	Verndale Street to Commonwealth Ave	00:25	D	01:17	**F**	00:43	**E**
Brighton								
Harvard Ave								
20	21	Commonwealth Ave to Brighton Ave	00:59	**E**	01:24	**F**	00:56	**E**
Brighton Ave								
21	22	Harvard Ave to Allston Street	00:29	D	00:03	A	00:16	C
22	23	Allston Street to Cambridge Street & North Beacon Street	00:12	B	00:00	A	00:12	B
Cambridge Street								
23	24	Brighton Ave & North Beacon Street to Harvard Ave	00:48	**E**	00:11	B	00:42	**E**
24	25	Harvard Ave to Lincoln Street	00:08	B	00:12	B	00:16	C
25	26	Lincoln Street to North Harvard Street	00:50	**E**	00:25	C	00:52	**E**
North Harvard Street								
26	27	Cambridge Street to Western Ave	00:45	**E**	00:19	C	00:31	D
27	28	Western Ave to Soldiers Field Rd	00:55	**E**	00:16	C	01:11	**F**
Cambridge								
Larz Anderson Bridge								
28	29	Soldiers Field Road to Memorial Drive	00:25	C	00:24	C	00:33	D
JFK Boulevard (formerly Boylston Street)								
29	30	Memorial Drive to Mount Auburn Street	00:38	D	00:59	**E**	00:37	D
30	31	Mount Auburn Street to Mass. Ave.	00:20	C	00:13	B	00:17	C
31	32	Mass. Ave to Garden Street	00:28	D	00:09	B	00:21	C
Average Segment Delay			00:26	D	00:22	C	00:26	D
Cumulative Average Arterial Delay			13:13		11:09		13:33	

FIGURE 4

Boston MPO Region Congestion Management System

Bus Route #66 Corridor 1998 PM Peak Period Speed –Based Level of Service

PM Peak Period
Level of Service

- Level of Service F (Less than 7 MPH)
- Level of Service E (From 7 to 8.9 MPH)
- Level of Service D (From 9 to 12.9 MPH)
- Level of Service C (From 13 to 18.9 MPH)
- Level of Service B (From 19 to 24.9 MPH)
- Level of Service A (From 25 to 35 MPH)

FIGURE 5

Boston MPO Region Congestion Management System

Bus Route #66 Corridor 1998 AM Peak Period Delay –Based Level of Service

AM Peak Period
Level of Service

- Level of Service F (60+ Sec. Delay)
- Level of Service E (41 –60 Sec. Delay)
- Level of Service D (26 –40 Sec. Delay)
- Level of Service C (16 –25 Sec. Delay)
- Level of Service B (6 –15 Sec. Delay)
- Level of Service A (5 Sec. or Less Delay)

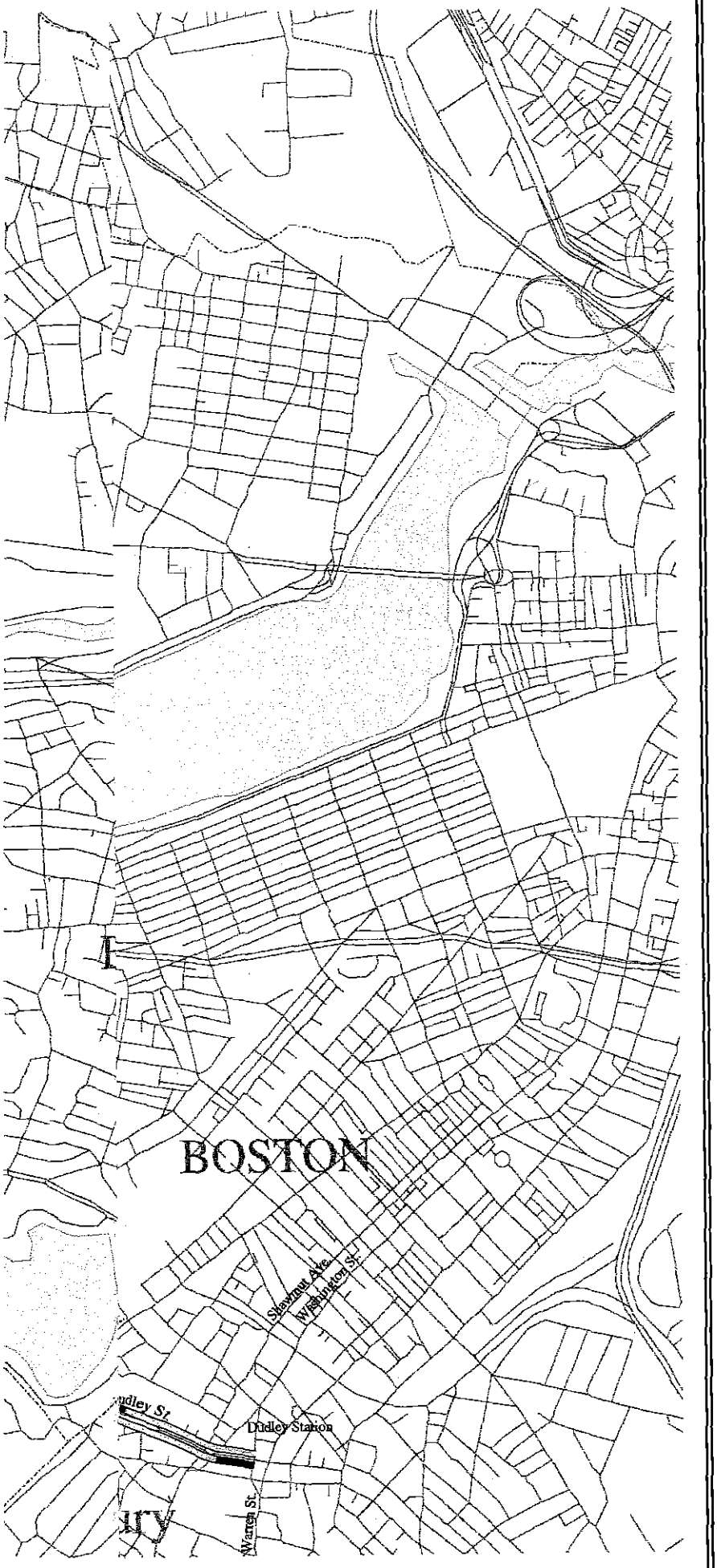


FIGURE 6

Boston MPO Region Congestion Management System

Bus Route #66 Corridor 1998 Midday Period Delay –Based Level of Service

Midday Period
Level of Service

- Level of Service F (60+ Sec. Delay)
- Level of Service E (41 –60 Sec. Delay)
- Level of Service D (26 –40 Sec. Delay)
- Level of Service C (16 –25 Sec. Delay)
- Level of Service B (6 –15 Sec. Delay)
- Level of Service A (5 Sec. or Less Delay)

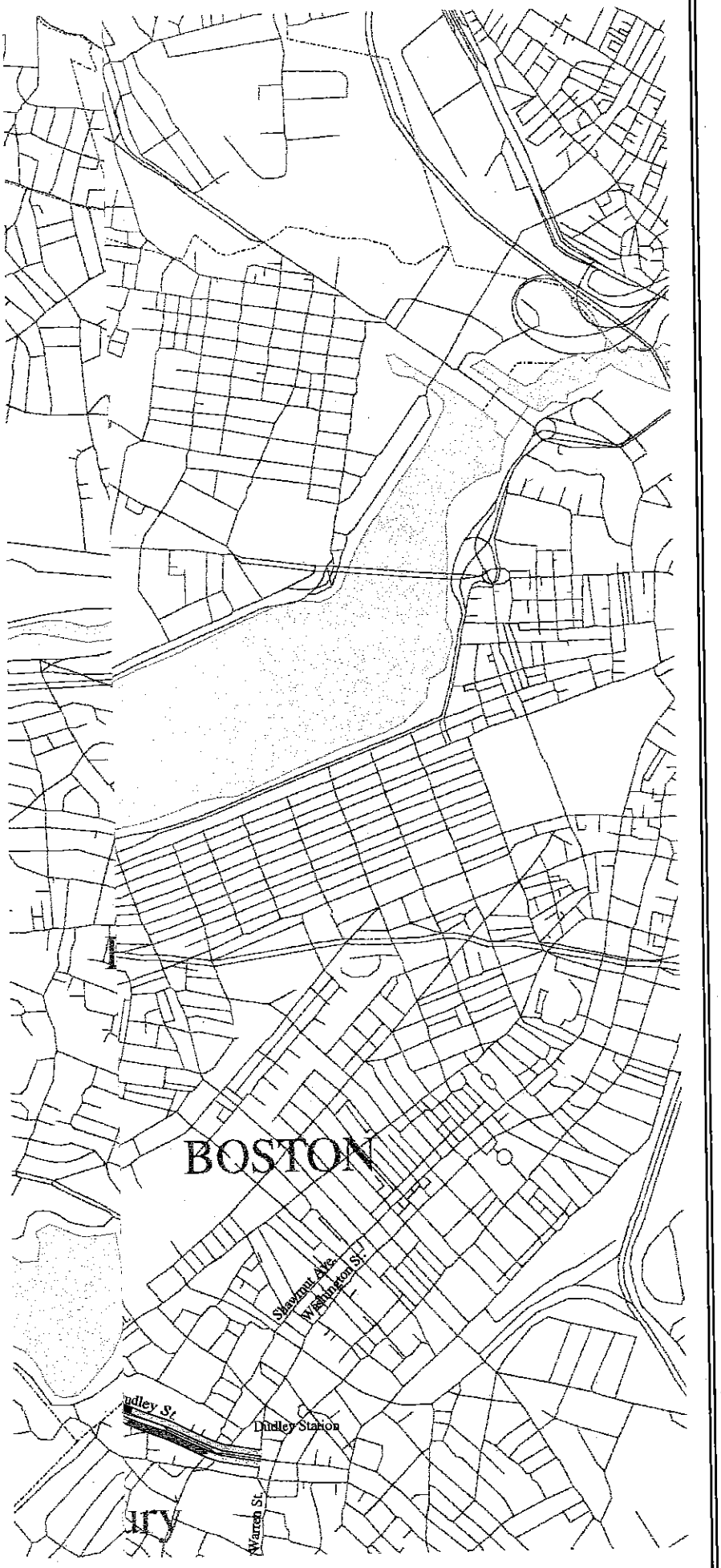


FIGURE 7

Boston MPO Region Congestion Management System

Bus Route #66 Corridor 1998 PM Peak Period Delay –Based Level of Service

PM Peak Period
Level of Service

- Level of Service F (60+ Sec. Delay)
- Level of Service E (41 –60 Sec. Delay)
- Level of Service D (26 –40 Sec. Delay)
- Level of Service C (16 –25 Sec. Delay)
- Level of Service B (6 –15 Sec. Delay)
- Level of Service A (5 Sec. or Less Delay)

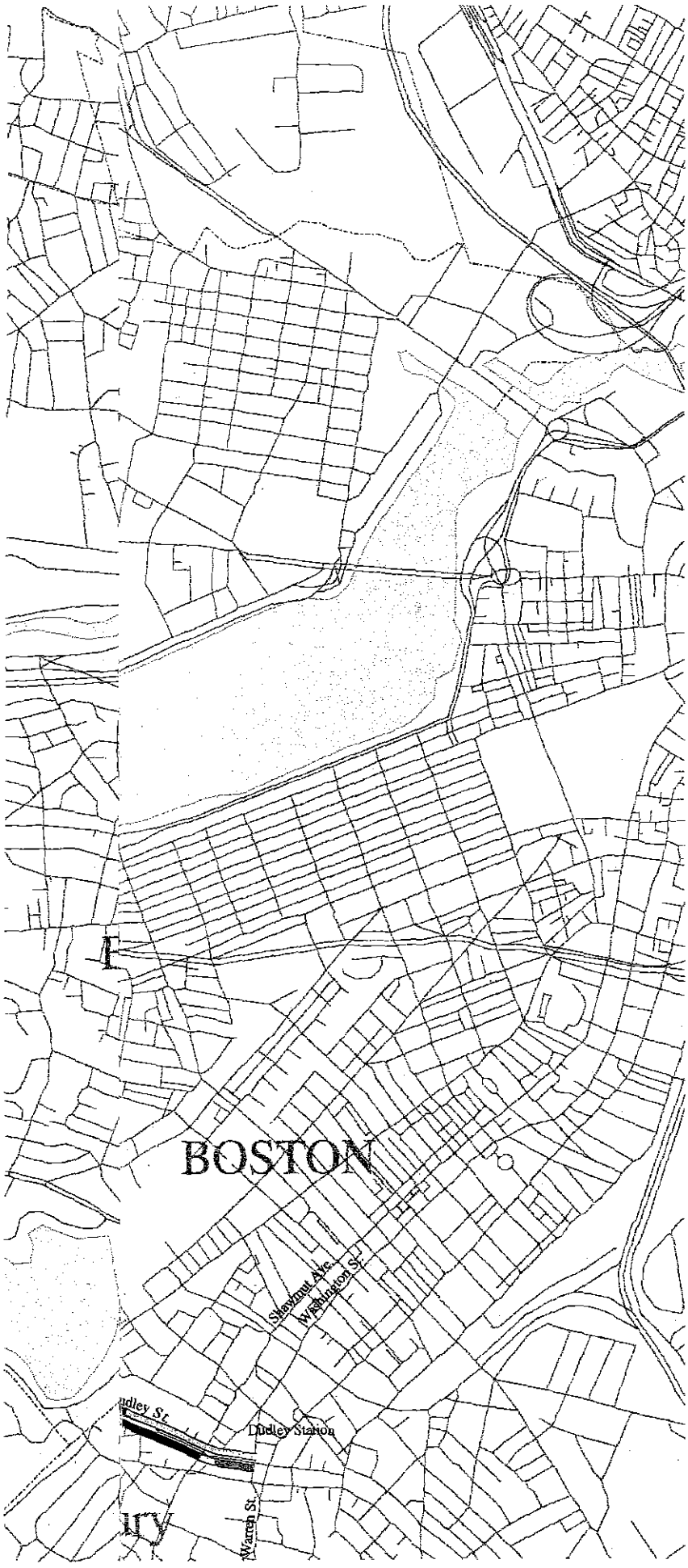


FIGURE 8

Boston MPO Region Congestion Management System

Bus Route #66 Inbound Corridor

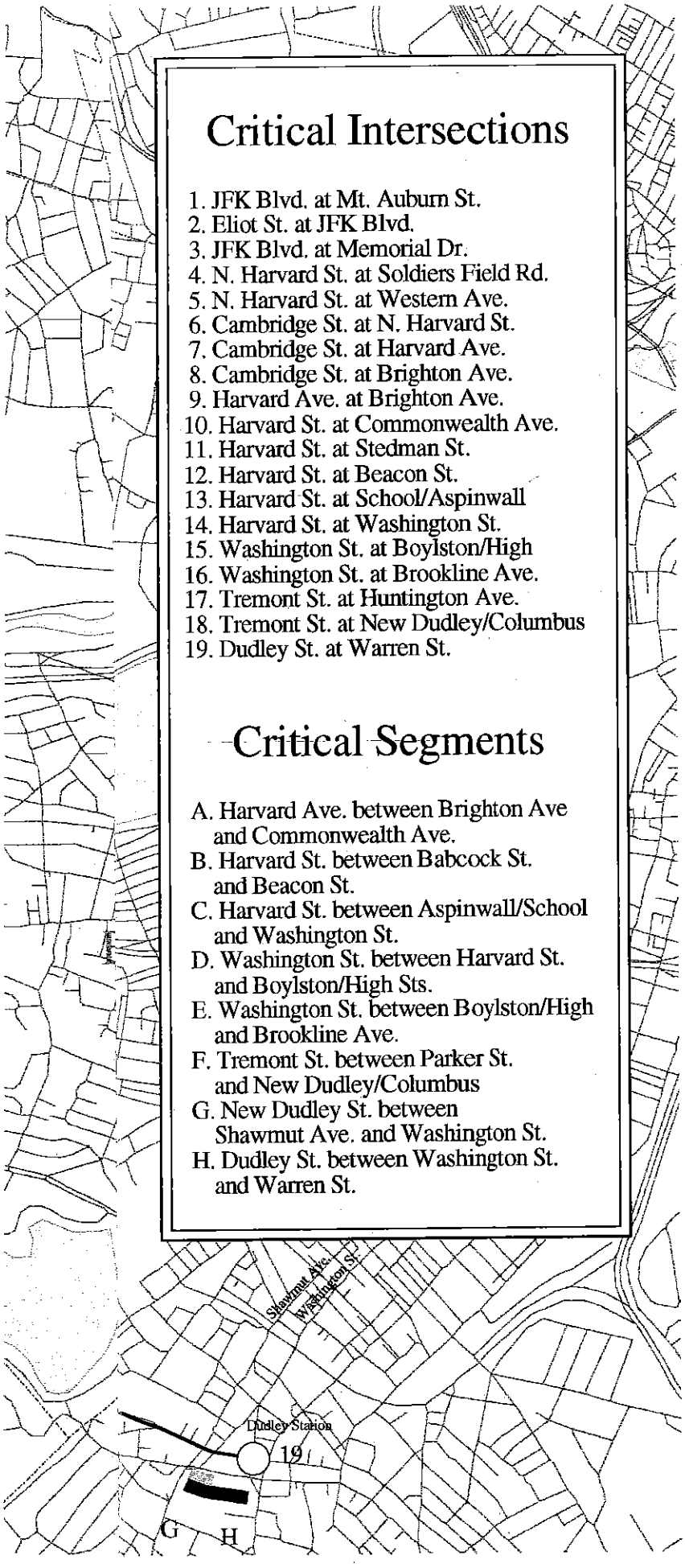
1998 Problem Areas: Critical Segments and Intersections

Critical Segments

- AM Peak Period
- Midday Period
- PM Peak Period

Critical Intersections

- AM Peak Period
- Midday Period
- PM Peak Period



Critical Intersections

1. JFK Blvd. at Mt. Auburn St.
2. Eliot St. at JFK Blvd.
3. JFK Blvd. at Memorial Dr.
4. N. Harvard St. at Soldiers Field Rd.
5. N. Harvard St. at Western Ave.
6. Cambridge St. at N. Harvard St.
7. Cambridge St. at Harvard Ave.
8. Cambridge St. at Brighton Ave.
9. Harvard Ave. at Brighton Ave.
10. Harvard St. at Commonwealth Ave.
11. Harvard St. at Stedman St.
12. Harvard St. at Beacon St.
13. Harvard St. at School/Aspinwall
14. Harvard St. at Washington St.
15. Washington St. at Boylston/High
16. Washington St. at Brookline Ave.
17. Tremont St. at Huntington Ave.
18. Tremont St. at New Dudley/Columbus
19. Dudley St. at Warren St.

Critical Segments

A. Harvard Ave. between Brighton Ave and Commonwealth Ave.
B. Harvard St. between Babcock St. and Beacon St.
C. Harvard St. between Aspinwall/School and Washington St.
D. Washington St. between Harvard St. and Boylston/High Sts.
E. Washington St. between Boylston/High and Brookline Ave.
F. Tremont St. between Parker St. and New Dudley/Columbus
G. New Dudley St. between Shawmut Ave. and Washington St.
H. Dudley St. between Washington St. and Warren St.

FIGURE 9

Boston MPO Region Congestion Management System

Bus Route #66 Outbound Corridor

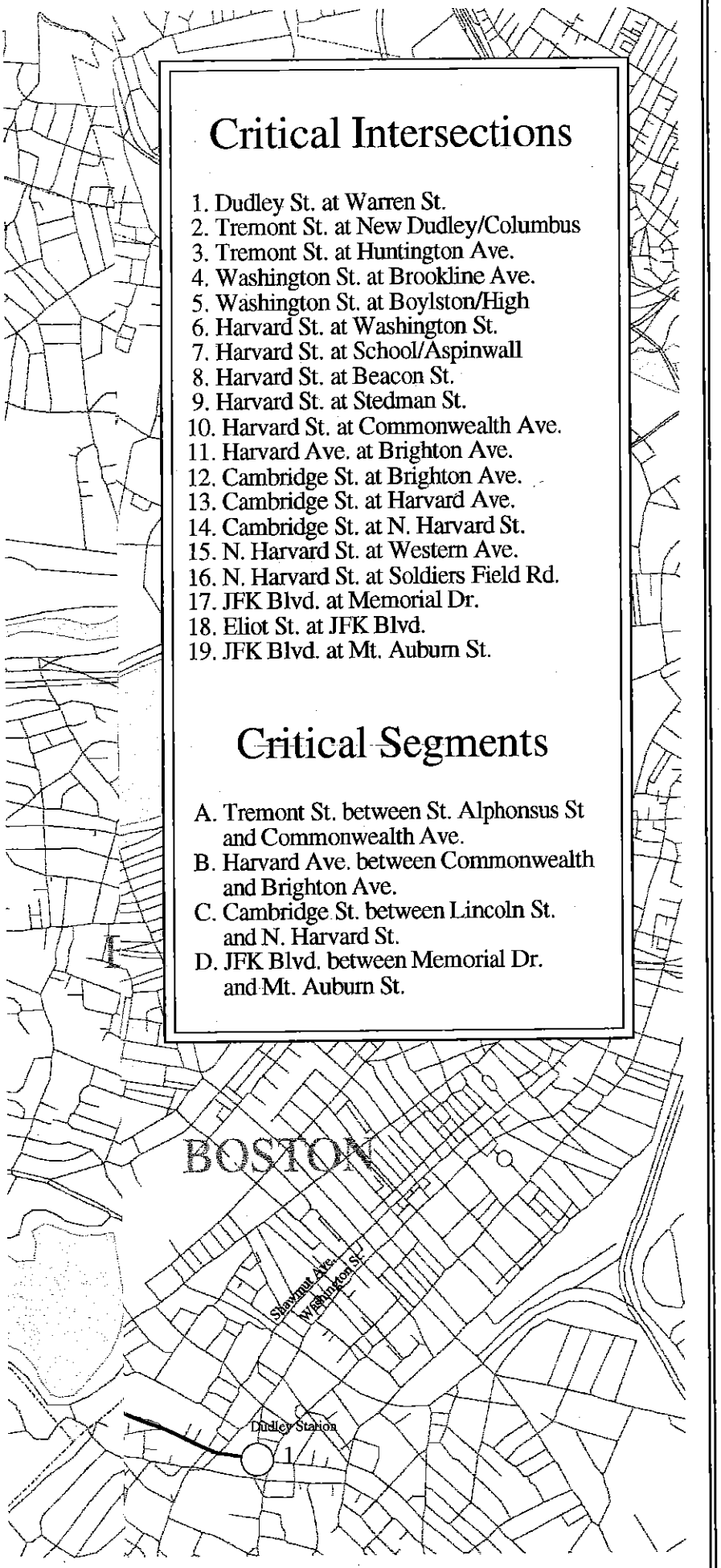
1998 Problem Areas: Critical Segments and Intersections

Critical Segments

- AM Peak Period
- Midday Period
- PM Peak Period

Critical Intersections

- AM Peak Period
- Midday Period
- PM Peak Period



Critical Intersections

1. Dudley St. at Warren St.
2. Tremont St. at New Dudley/Columbus
3. Tremont St. at Huntington Ave.
4. Washington St. at Brookline Ave.
5. Washington St. at Boylston/High
6. Harvard St. at Washington St.
7. Harvard St. at School/Aspinwall
8. Harvard St. at Beacon St.
9. Harvard St. at Stedman St.
10. Harvard St. at Commonwealth Ave.
11. Harvard Ave. at Brighton Ave.
12. Cambridge St. at Brighton Ave.
13. Cambridge St. at Harvard Ave.
14. Cambridge St. at N. Harvard St.
15. N. Harvard St. at Western Ave.
16. N. Harvard St. at Soldiers Field Rd.
17. JFK Blvd. at Memorial Dr.
18. Eliot St. at JFK Blvd.
19. JFK Blvd. at Mt. Auburn St.

Critical Segments

A. Tremont St. between St. Alphonsus St and Commonwealth Ave.
B. Harvard Ave. between Commonwealth and Brighton Ave.
C. Cambridge St. between Lincoln St. and N. Harvard St.
D. JFK Blvd. between Memorial Dr. and Mt. Auburn St.

Table 7

Bus Route 66 Improvement Study

Problem Segments and Intersections, Inbound

Inbound Segment	AM Peak				Midday Peak				PM Peak			
	Avg Speed	LOS	Avg Delay	LOS	Avg Speed	LOS	Avg Delay	LOS	Avg Speed	LOS	Avg Delay	LOS
Cambridge												
Eliot Street												
Eliot @ JFK Street			00:48	E			00:28	D			00:32	D
JFK Boulevard (Formerly Boylston Street)												
JFK Street @ Memorial Drive			01:09	F			00:16	C			00:33	D
Brighton												
North Harvard Street												
North Harvard st @ Western Ave			00:31	D			00:53	E			00:41	E
North Harvard St @ Cambridge Street			00:53	E			00:34	D			01:01	F
Cambridge Street												
Cambridge St @ Brighton Ave & North Beacon Street			00:27	D			00:50	E			00:19	C
Harvard Ave												
Brighton Ave to Commonwealth Ave	12.5	D			7.8	E			6.5	F		
Harvard Ave @ Commonwealth Ave			00:28	D			01:04	F			01:13	F
Brookline												
Harvard Street												
Harvard Street @ Stedman Street			00:14	B			00:17	C			00:40	E
Babcock Street to Beacon Street	7.7	E			9.4	D			8.4	E		
Harvard Street @ Beacon Street			00:45	E			00:23	C			00:28	D
Aspinwall &School Streets to Washington Street	13.6	C			8.5	E			6	F		
Harvard Street @ Washington Street			00:32	D			01:03	F			01:48	F
Washington Street												
Harvard Street to Rte 9 (Boylston & High Streets)	7.3	E			7	E			9.6	D		
Washington Street @ Rte 9 (Boylston & High Streets)			00:41	E			00:30	D			00:26	D
Rte 9 (Boylston & High Streets) to Brookline Ave	17.6	C			13.1	C			8	E		
Washington St @ Brookline Ave			00:23	C			00:17	C			00:40	E
Roxbury												
Huntington Ave												
Huntington Ave @ South Huntington Street			00:40	D			00:03	A			00:40	E
Huntington Ave @ Tremont Street			00:22	C			00:55	E			01:10	F
Tremont Street												
Parker Street to New Dudley Street	11	D			8.5	E			6.7	F		
Tremont Street to New Dudley Street			00:55	E			00:55	E			00:37	D
New Dudley Street												
Shawmut Ave to Washington Street	16.5	C			7.3	E			7.8	E		
Washington Street to Warren Street	9.3	D			10.3	D			8.6	E		

Table 8

Bus Route 66 Improvement Study

Problem Segments and Intersections, Outbound

Outbound Segment	AM Peak				Midday Peak				PM Peak			
	Avg Speed	LOS	Avg Delay	LOS	Avg Speed	LOS	Avg Delay	LOS	Avg Speed	LOS	Avg Delay	LOS
Roxbury												
Madison Park High School X-Walk to Columbus Ave			00:34	D			00:53	E			00:45	E
Tremont Street												
St Alphonsus Street to Huntington Ave (Rte 9)	8.3	E			10.3	D			7	E		
Tremont Street @ Huntington Ave			01:12	F			01:04	F			01:06	F
Brookline												
Harvard Street												
Harvard Street @ School Street & Aspinwall Street			00:45	E			00:41	E			00:38	D
Harvard Street @ Beacon Street			00:41	E			00:37	D			00:55	E
Harvard Street @ Commonwealth Ave			00:25	D			01:17	F			00:43	E
Brighton												
Harvard Ave												
Commonwealth Ave to Brighton Ave	10.4	D			5.8	F			8.9	E		
Harvard Ave @ Brighton Ave			00:59	E			01:24	F			00:56	E
Cambridge Street												
Cambridge St @ Harvard Ave			00:48	E			00:11	B			00:42	E
Lincoln Street to North Harvard Street	7.2	E			9.2	D			6.3	F		
Cambridge Street @ North Harvard Street			00:50	E			00:25	C			00:52	E
North Harvard Street												
North Harvard Street @ Western Ave			00:45	E			00:19	C			00:31	D
North Harvard Street @ Soldiers Field Rd			00:55	E			00:16	C			01:11	F
Cambridge												
JFK Boulevard (formerly Boylston Street)												
Memorial Drive to Mount Auburn Street	12.1	D			8.9	E			11.4	D		
JFK Boulevard @ Mount Auburn Street			00:38	D			00:59	E			00:37	D

Appendix

Chapter 11 provides a set of criteria for classifying arterials by function and design, and further defines ranges of average travel speed associated with given levels of service. Urban arterials are classified as either minor or principal, depending upon the purpose of the road. Principal arterials serve traffic traveling between major centers of urban activity. Minor arterials also serve this function, but to a lesser degree. They primarily provide access to adjacent land uses. Arterials are further classified by design, varying in the intensity of roadside development, speed limits, and signals per mile. Arterial design falls into three categories, suburban, intermediate, and urban. Suburban arterial design consists of low density roadside development, separate left-turn lanes, few signals per mile, no parking, and speed limits of 40 to 45 miles per hour. Intermediate arterial design consists of a higher density of roadside development, a mix of separate and continuous left-turn lanes, 4 to 10 signals per mile spaced for good progression, segments where parking is permitted, and speed limits between 30 and 40 miles per hour.

Combining the function and design criteria, the Highway Capacity Manual classifies arterials as follows:

I A principal arterial of suburban design.
II A principal arterial of either intermediate design or urban design or a minor arterial of either suburban or intermediate design.
III A principal arterial of urban design or a minor arterial of either intermediate or urban design

The levels of service vary by arterial class, as listed in Table 1.

Table 1 Arterial Levels of Service

	Arterial Classification		
	I	II	III
Range of free-flow speeds (mph)	45 to 35	35 to 30	35 to 25
Typical free-flow speeds (mph)	40	33	27
Level of Service	Average Travel Speed (MPH)		
A	≥ 35	≥ 30	≥ 25
B	≥ 28	≥ 24	≥ 19
C	≥ 22	≥ 18	≥ 13
D	≥ 17	≥ 14	≥ 9
E	≥ 13	≥ 10	≥ 7
F	< 13	< 10	< 7

Appendix E:

Traffic Operations Analysis

Appendix E

Traffic Operations Analysis

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Summary of Contents/Background

Using the level-of-service analysis procedures of the 1997 Highway Capacity Manual, CTPS analyzed the capacity conditions at selected intersections along the route using data collected on traffic volumes and signal and intersection characteristics. CTPS calculated the seconds of delay, the level of service, and the queue length in cars and in feet for each approach to the intersections for three time periods. Since any improvement strategy will have to take signal coordination into account, coordinated traffic signal systems were identified.

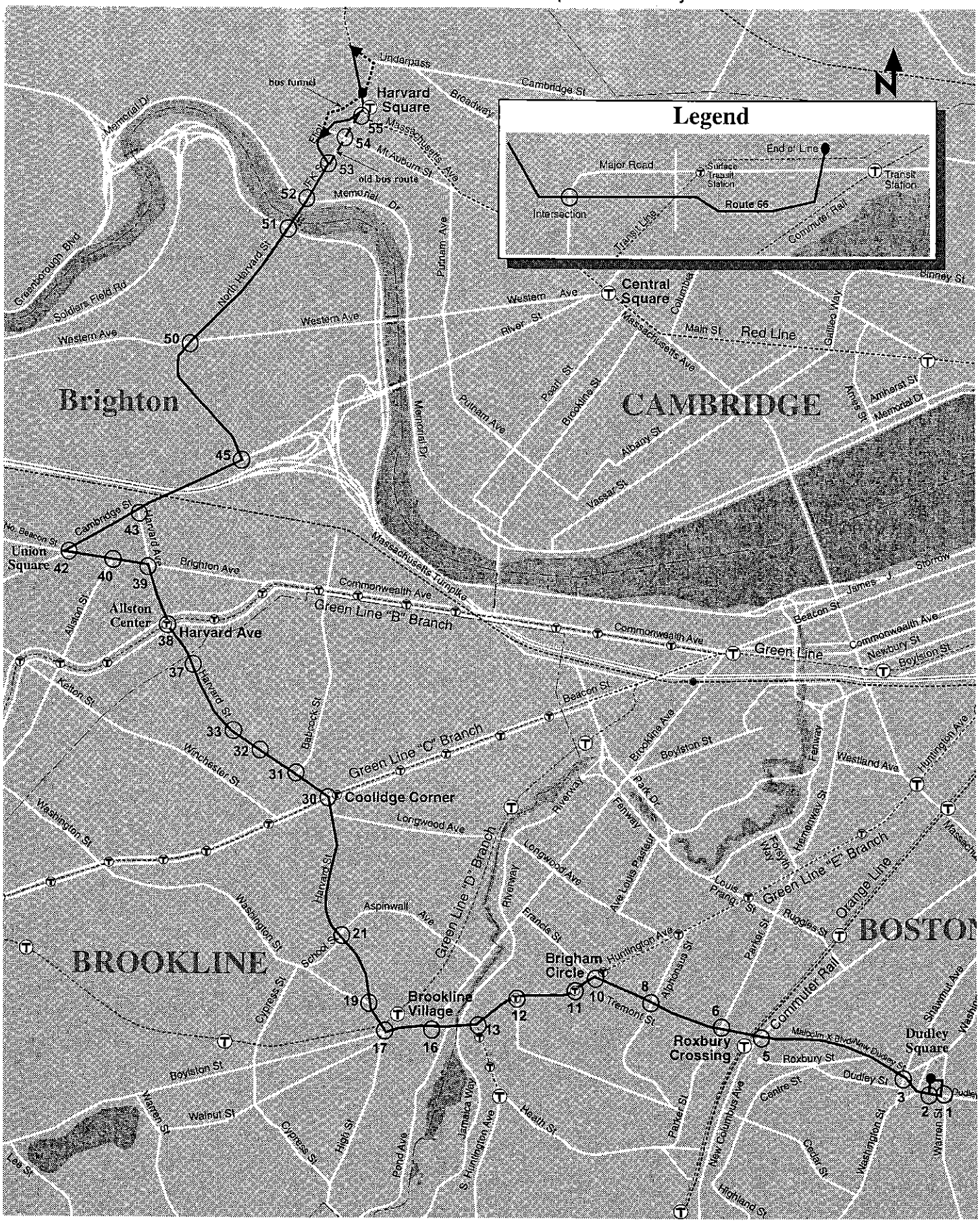
The results establish a baseline for measuring the improvement potential of a set of congestion reduction strategies to be developed with the help of the city and town engineers that will hopefully reduce variability of the travel time for the Route 66 buses.

Of the 60 total intersections along the bus route, CTPS analyzed 31 signalized intersections to identify the congested movements during the three peak hours; 24 of these 31 were also analyzed for the midday peak hour. The analysis focused on signalized intersections, because delay is more readily addressable than at unsignalized intersections.

Following the work on the travel time study of the bus route,[1] CTPS collected turning movement volumes, signal timings, and signal permit and lane geometry information for use in highway capacity analysis of several high-priority intersections. The average speed and delay for the bus through movements at the intersections had to be LOS E or F to be included on the "priority" list. In addition to the turning movement volumes that were collected, pre-existing turning movement volume data was available from recent planning efforts. Where possible, this pre-existing data was incorporated into the analysis. Figure 1 shows the path of Bus Route 66 and the locations of the intersections for which the LOS analysis was conducted.

[1] CTPS, "GPS Travel Time Data Collection and Identification of Priority Locations for Intersection Level of Service Analysis (Bus Route 66 Study)", Nov. 19, 1998, pp. 6-20.

Figure 1
Intersections Identified for LOS Analysis
MBTA Bus Route 66 Arterial Improvement Study


Legend
Major Road
Surface Transit Station
End of Line
Transit Station
Intersection
Route 66
Transit Lines
Commuter Rail
N
Harvard Square
Underpass
bus tunnel
Cambridge St
Broadway
Massachusetts Ave
Mt Auburn St
old bus route
Memorial Dr
North Harvard St
Soldiers Field Rd
Greenough Blvd
Western Ave
Central Square
Main St
Red Line
Brighton
CAMBRIDGE
Putnam Ave
Pearl St
Brookline St
Albany St
Vassar St
Amherst St
Union Square
Allston Center
Harvard Ave
Brighton Ave
Commonwealth Ave
Green Line "B" Branch
Green Line
Beacon St
Boylston St
Newbury St
Kelton St
Harvard St
Babcock St
Winchester St
Green Line "C" Branch
Coolidge Corner
Longwood Ave
Washington St
Aspinwall Ave
School St
Green Line "D" Branch
BROOKLINE
Brookline Village
Brigham Circle
Huntington Ave
Tremont St
Roxbury Crossing
Roxbury St
Dudley Square
Dudley St
Commuter Rail
Orange Line
Green Line "E" Branch
Ruggles St
Parker St
Francis St
Riverway
Fenway
Brookline Ave
Westland Ave
Hemenway St
Boylston St
Beacon St
Cypress St
Walnut St
Warren St
Centre St
Heath St
Pond Ave
Jamaica Way
Perkins St
New Columbus Ave
Cedar St
Washington St
Warren St
Blinney St
Gallivan Way
Columbia
Memorial Dr
Putnam Ave
Mass Turnpike
James J.
Stanley
Ashford St
Aberdeen St
Lee St
Ipswich St
Shawmut Ave
Malcolm X Blvd
View Bridge
Louis Prang St
Ave Louis Pasteur
Yawkey Way
Fenway
Park Dr
Longwood Ave
Francis St
Riverway
Aspinwall Ave
Harvard St
Washington St
School St
Cypress St
Boylston St
Warren St
Walnut St
Pond Ave
Jamaica Way
S Huntington Ave
Heath St
Parker St
New Columbus Ave
Centre St
Cedar St
Washington St
Warren St
Highland St
Dudley St
Roxbury St
Melnea X Blvd
View Bridge
Tremont St
Aphonsus St
Huntington Ave
Francis St
Ruggles St
Parker St
Louis Prang St
Ave Louis Pasteur
Yawkey Way
Fenway
Park Dr
Longwood Ave

A. Turning Movement Volumes

Turning movement volumes for sixteen intersections were collected in 1998. Data collection consisted of 15-minute increments, during three time periods: morning peak-period, from 7:00 to 9:00 a.m.; evening peak-period, from 4:00 to 6:00 p.m.; and, the midday period, from 12:00 to 2:00 p.m.

The Highway Capacity Manual (HCM) analysis for each intersection used a single corridor-wide peak-hour for a.m., midday, and p.m. periods. A corridor-wide peak-hour for each time period was calculated by adding the total turning movement volume for each intersection in 15-minute increments. The selected peak-hour was the hour that had the highest total volume in the corridor. This method was chosen since many of the signals along the route operate in coordination with other signals. The three peak hours were determined to be 7:45-8:45 a.m., 12:15-1:15 p.m., and 5:00-6:00 p.m.

The intersections listed in Table 1 (on the following page) were found to have the highest total hourly throughput by time period. They are presented to indicate the magnitude of traffic intersecting the route throughout the day. In several instances, as indicated, the Route 66 buses run on both the cross street and the major arterial.

The illustrations of the turning movement volumes by intersection and peak hour are shown in Figures 2 through 10, on the following pages.

Table 1. Intersections with the Highest Total Hourly Vehicle Throughput

Intersection	Highest Total Hourly Vehicle Throughput	Bus Use of the Route
A.M. Peak		
JF Kennedy Boulevard at Memorial Drive	4058 total vehicles	bus on the cross street
Cambridge Street at North Harvard Street	3956	bus on both the cross street and the major arterial
Washington Street at Boylston and High Streets	3862	bus on both the cross street and the major arterial
Midday		
Tremont Street at New Dudley Street	3355	bus on both the cross street and the major arterial
Washington Street at Boylston and High Streets	3192	bus on both the cross street and the major arterial
Harvard Street at Beacon Street	3179	bus on the cross street
P.M. Peak		
Cambridge Street at North Harvard Street	3993	bus on both the cross street and the major arterial
Washington Street at Boylston and High Streets	3980	bus on both the cross street and the major arterial
Tremont Street at New Dudley Street	3961	bus on both the cross street and the major arterial

Figure 2
Turning Movement Volumes at Bus Route 66 Intersections in Roxbury (A.M. Peak Hour, 1998)

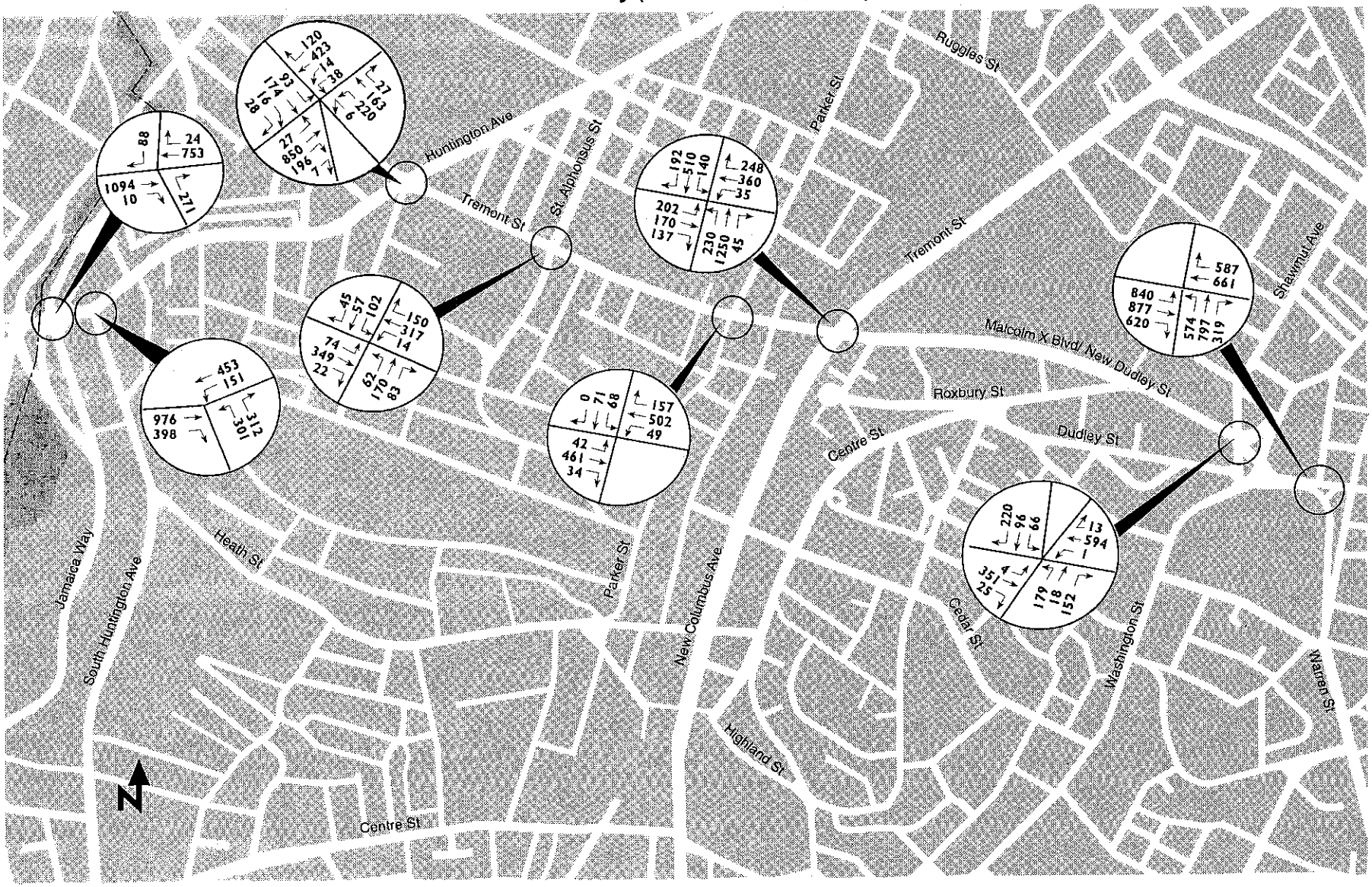


Figure 3
Turning Movement Volumes at Bus Route 66 Intersections in Brookline (A.M. Peak Hour, 1998)

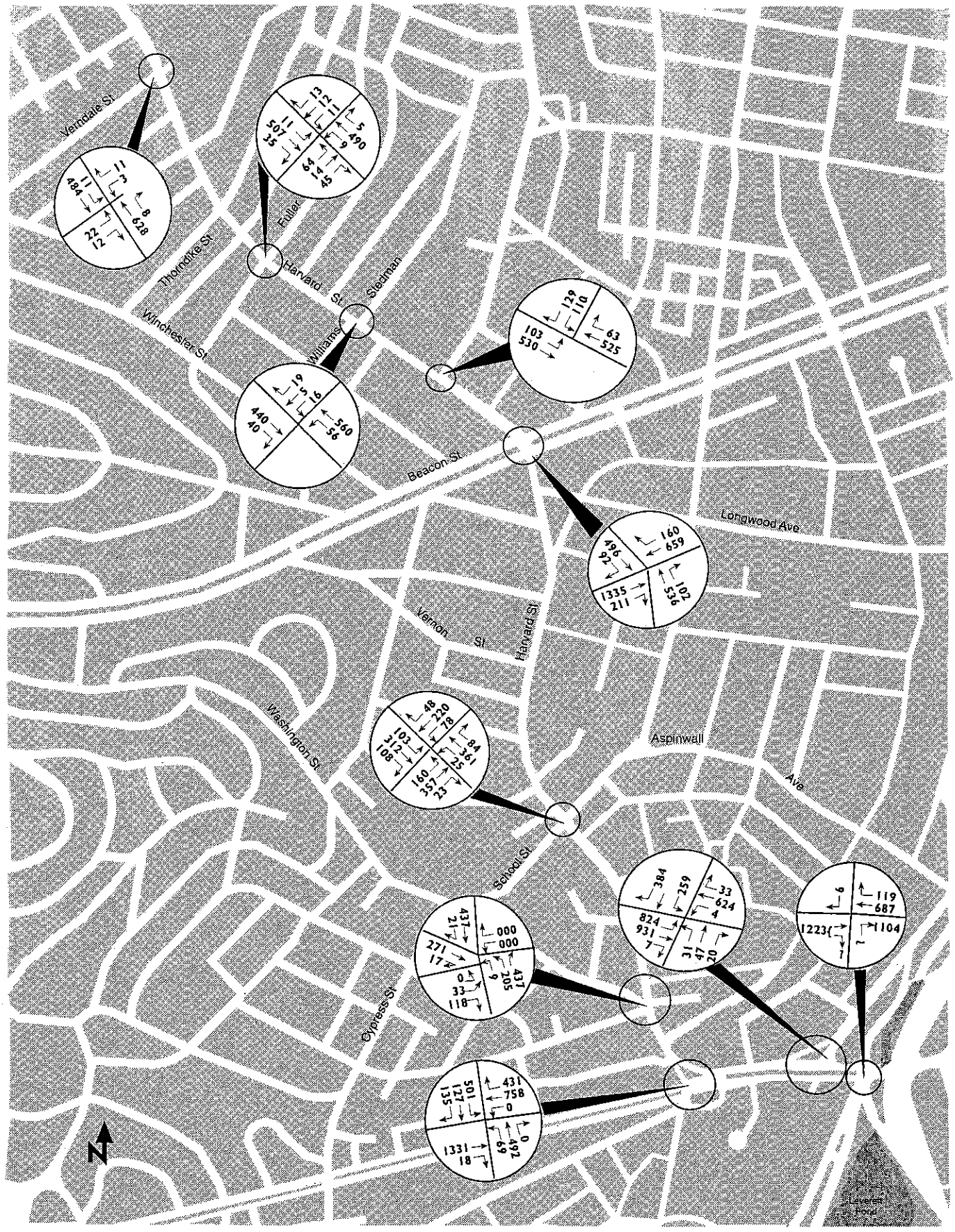


Figure 4
Turning Movement Volumes at Bus Route 66 Intersections in Cambridge & Allston/Brighton (A.M. Peak Hour, 1998)

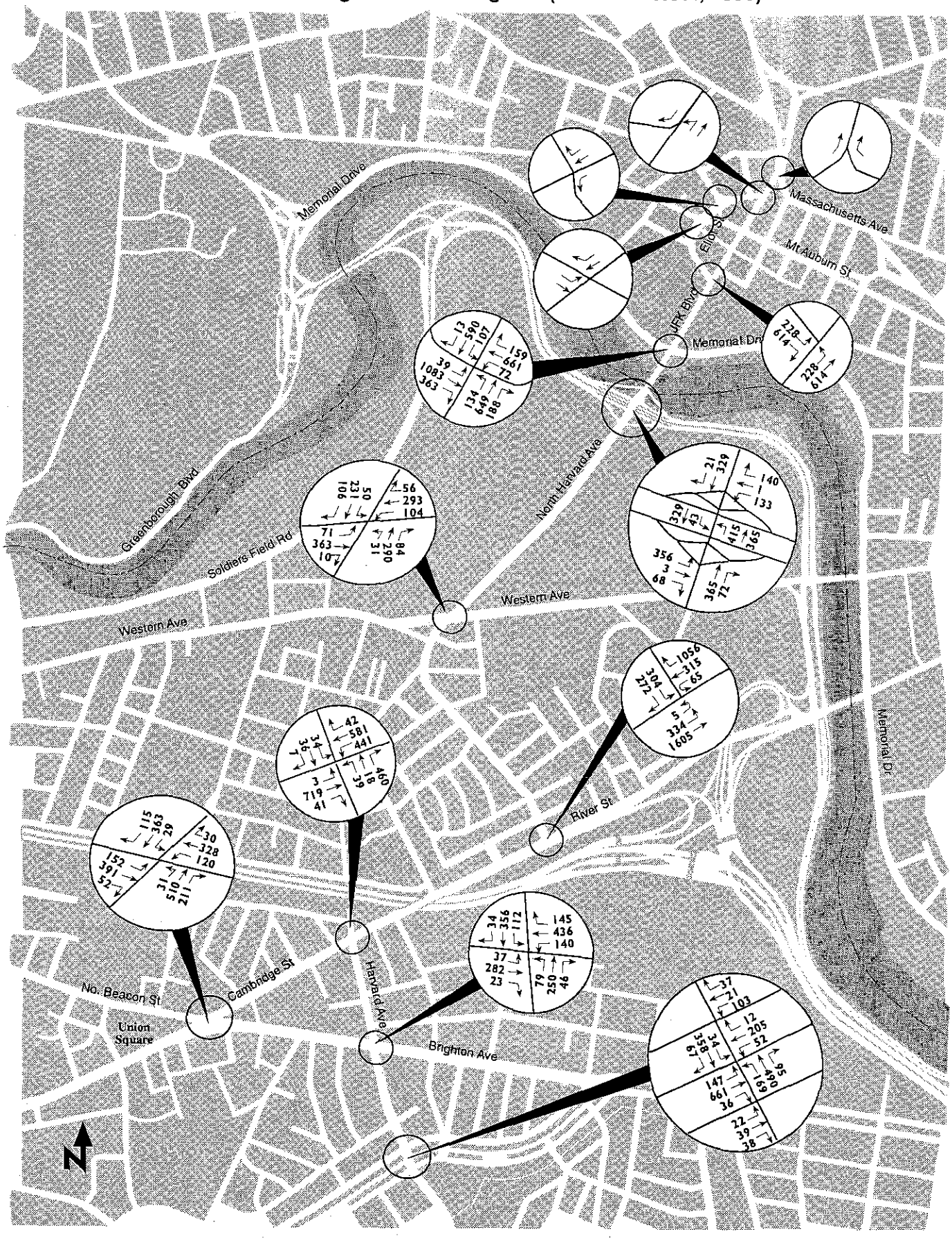


Figure 5
Turning Movement Volumes at Bus Route 66 Intersections in Roxbury (Midday Peak Hour, 1998)

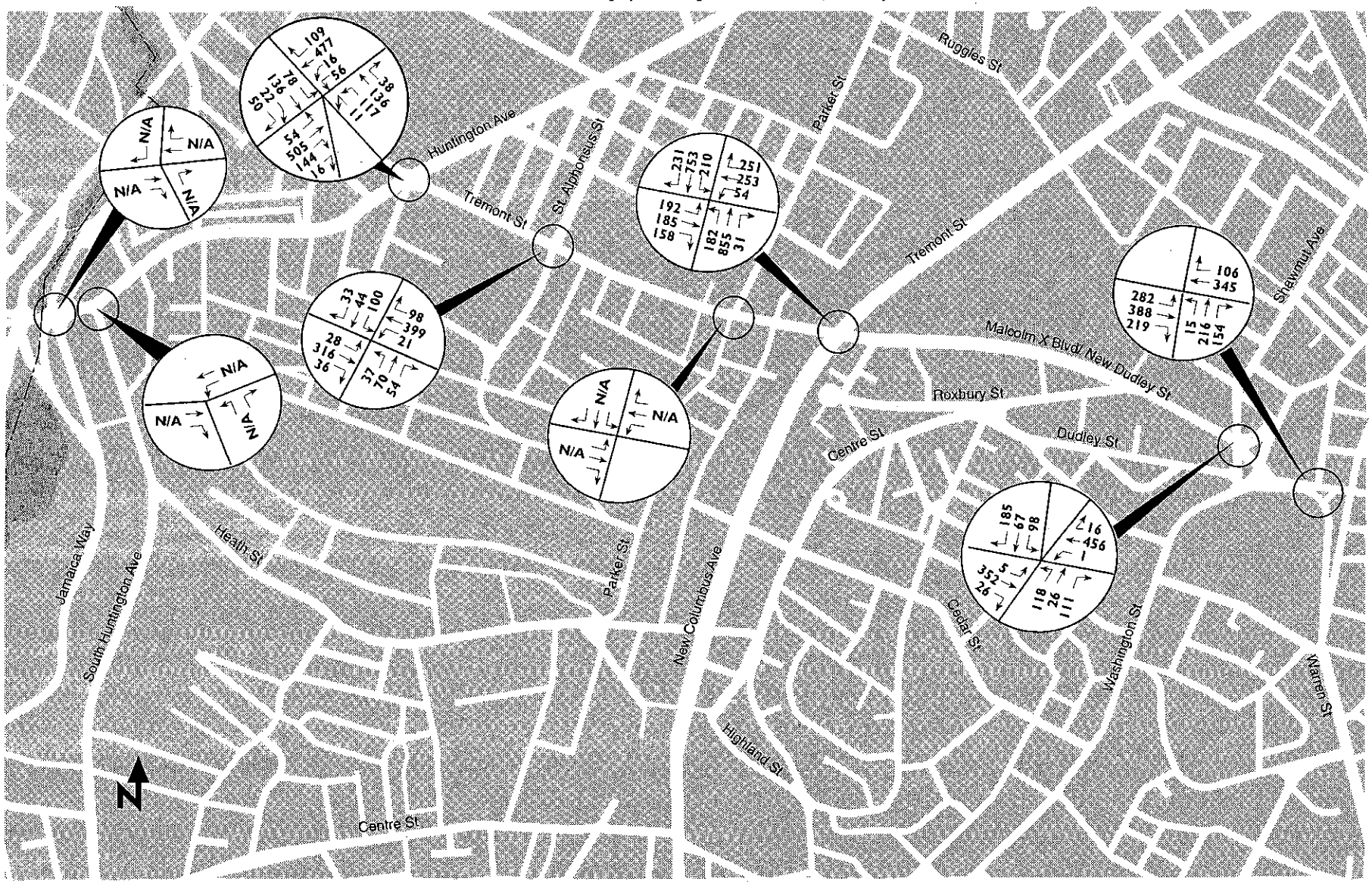

Huntington Ave
Tremont St
St Alphonsus St
Parker St
Ruggles St
Tremont St
Malcolm X Blvd/ New Dudley St
Roxbury St
Centre St
Dudley St
Shawmut Ave
Jamaica Way
South Huntington Ave
Heath St
Parker St
New Columbus Ave
Cedar St
Washington St
Warren St
Highland St
Centre St
N
N/A
109 477 16 56 38 136 117 11 54 505 144 16 78 136 50 50
231 753 210 251 253 54 192 185 158 182 855 31
33 44 100 98 399 21 28 316 36 37 70 54
106 345 282 388 219 15 216 154
185 67 98 16 456 1 5 352 26 118 26 111

Figure 6
Turning Movement Volumes at Bus Route 66 Intersections in Brookline (Midday Peak Hour, 1998)

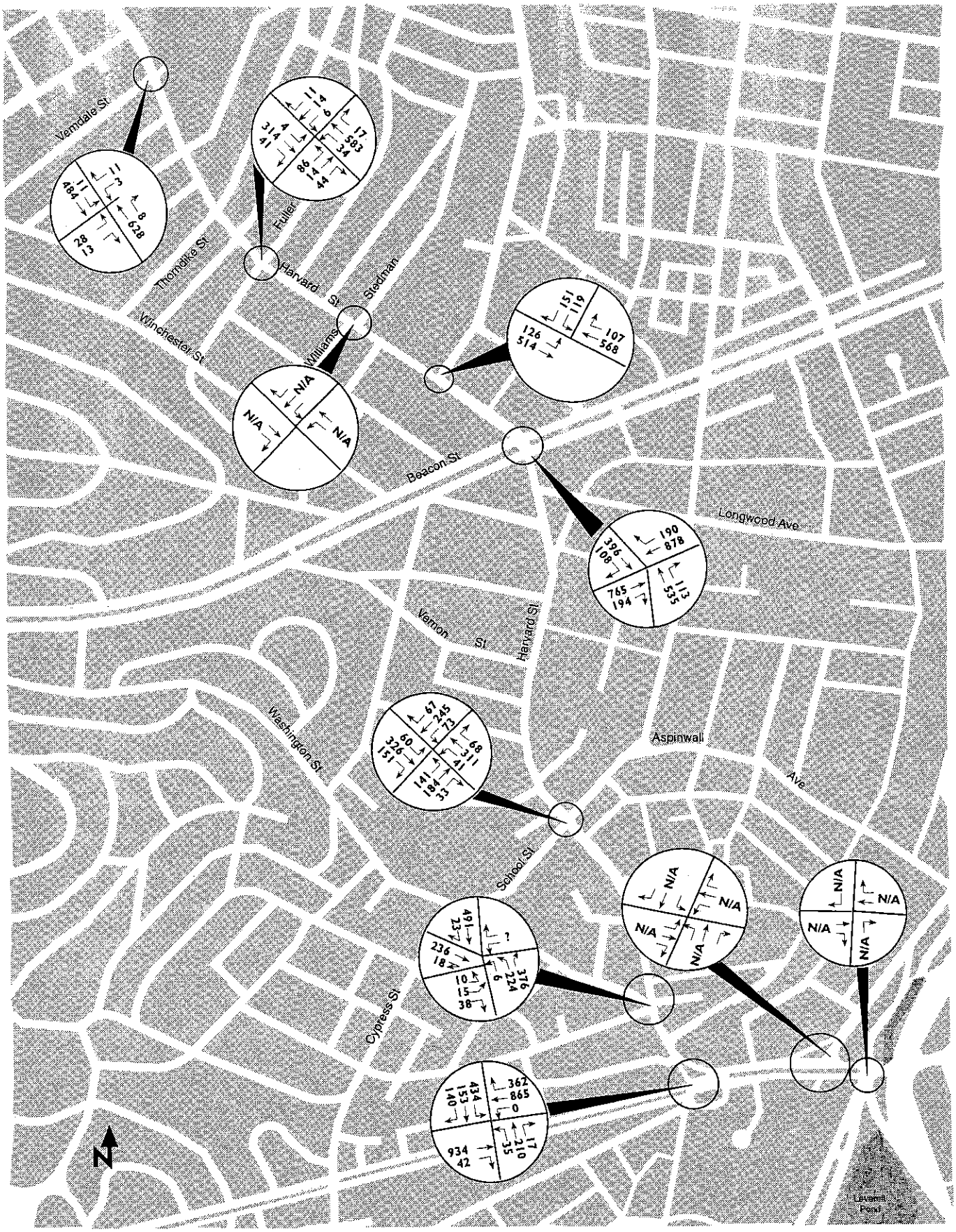


Figure 7
Turning Movement Volumes at Bus Route 66 Intersections in Cambridge & Allston/Brighton (Midday Peak Hour, 1998)

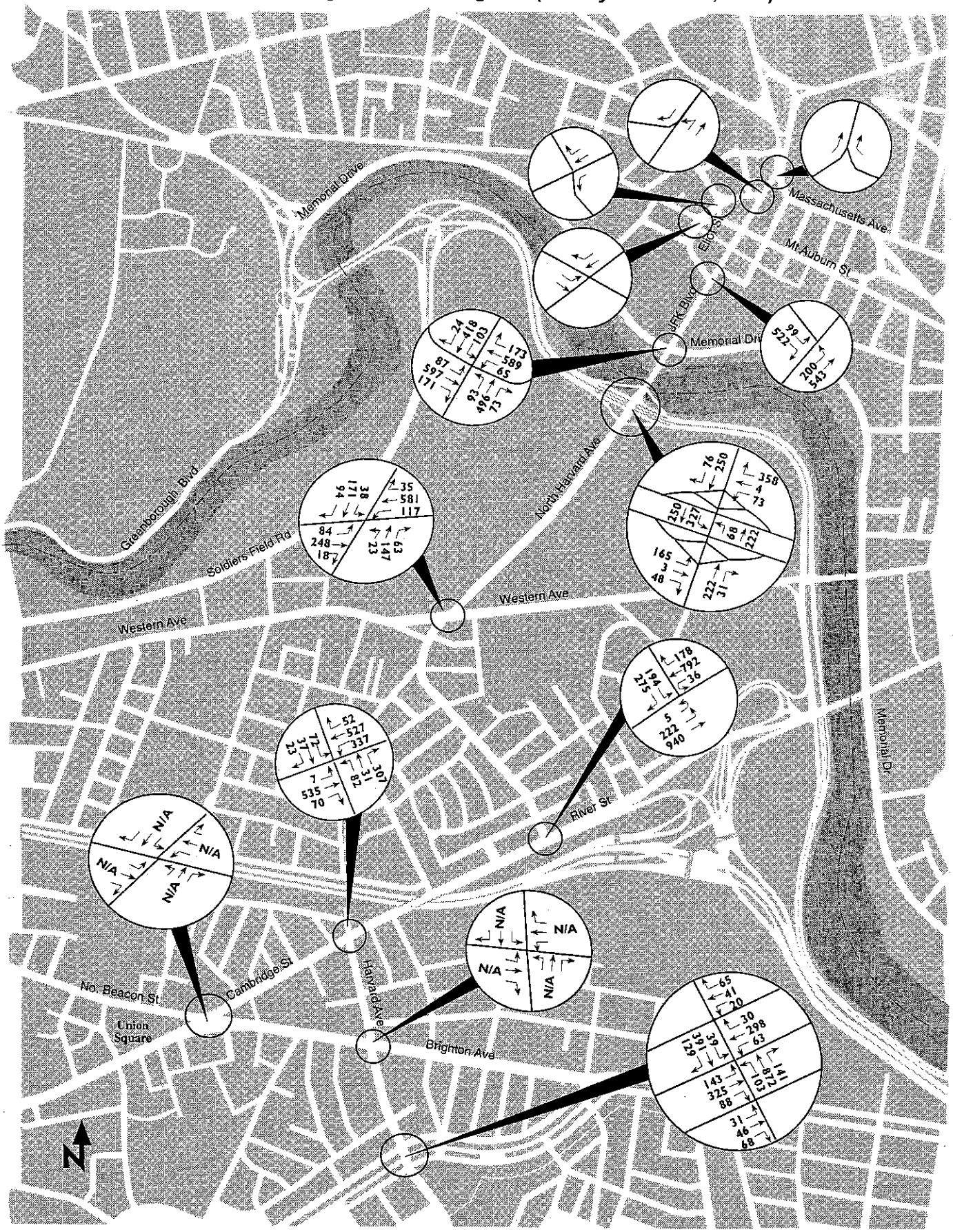

Memorial Drive
Massachusetts Ave
Mt Auburn St
Eliot St
JFK Blvd
Memorial Dr
Greenborough Blvd
Soldiers Field Rd
North Harvard Ave
Western Ave
Western Ave
River St
Memorial Dr
Cambridge St
Harvard Ave
No. Beacon St
Union Square
Brighton Ave
N/A
N
24 418 103 173 589 65 87 597 171 93 496 73
99 522 200 543
38 171 94 35 581 117 84 248 18 63 147 23
76 250 358 4 73 350 327 68 222 165 48 222 31
178 792 36 194 25 5 222 940
52 527 337 72 37 23 7 535 70 307 31 82
65 41 20 30 298 63 129 36 143 325 88 141 212 101 31 46 68

Figure 8
Turning Movement Volumes at Bus Route 66 Intersections in Roxbury (P.M. Peak Hour, 1998)

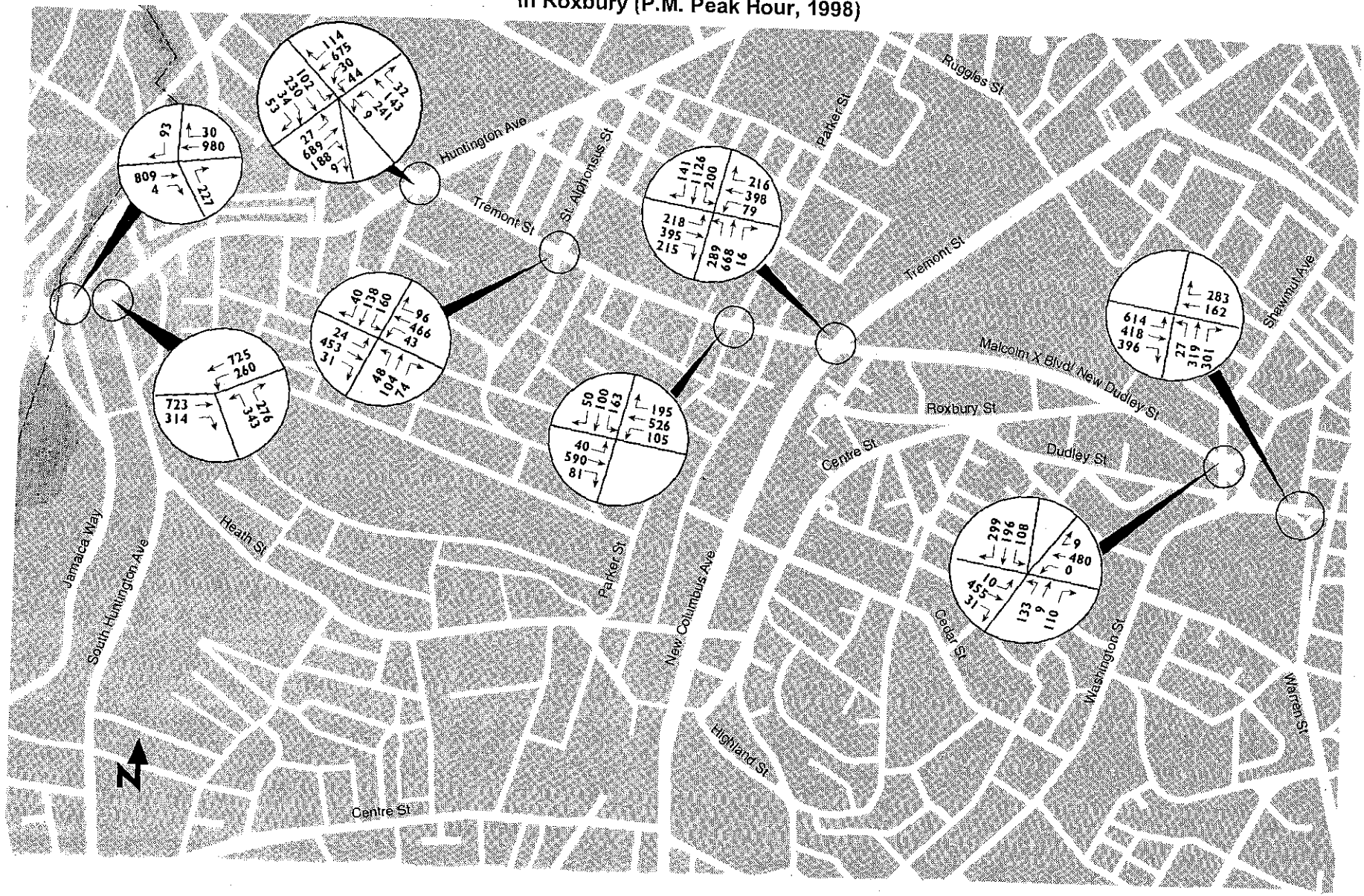


Figure 9
Turning Movement Volumes at Bus Route 66 Intersections in Brookline (P.M. Peak Hour, 1998)

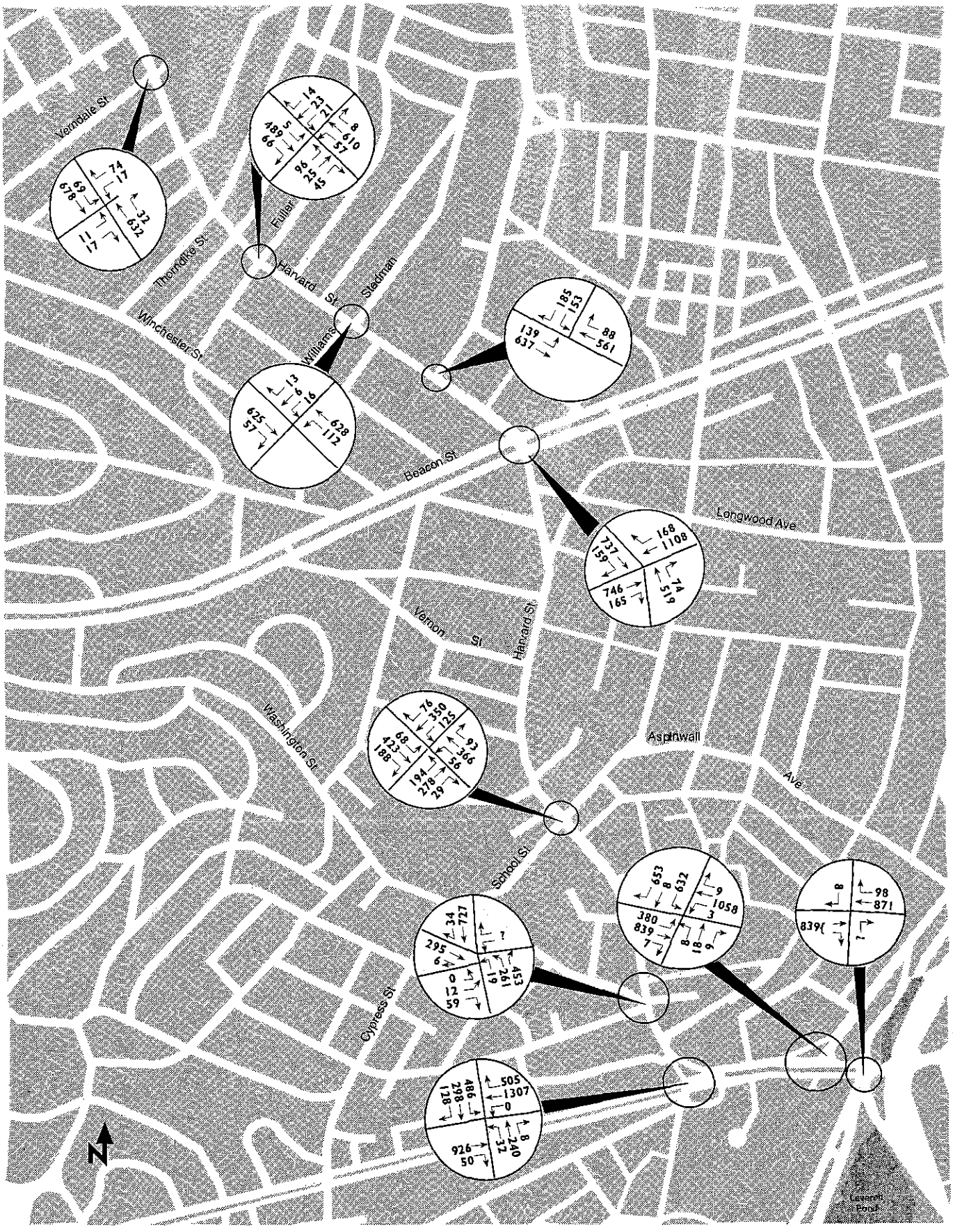
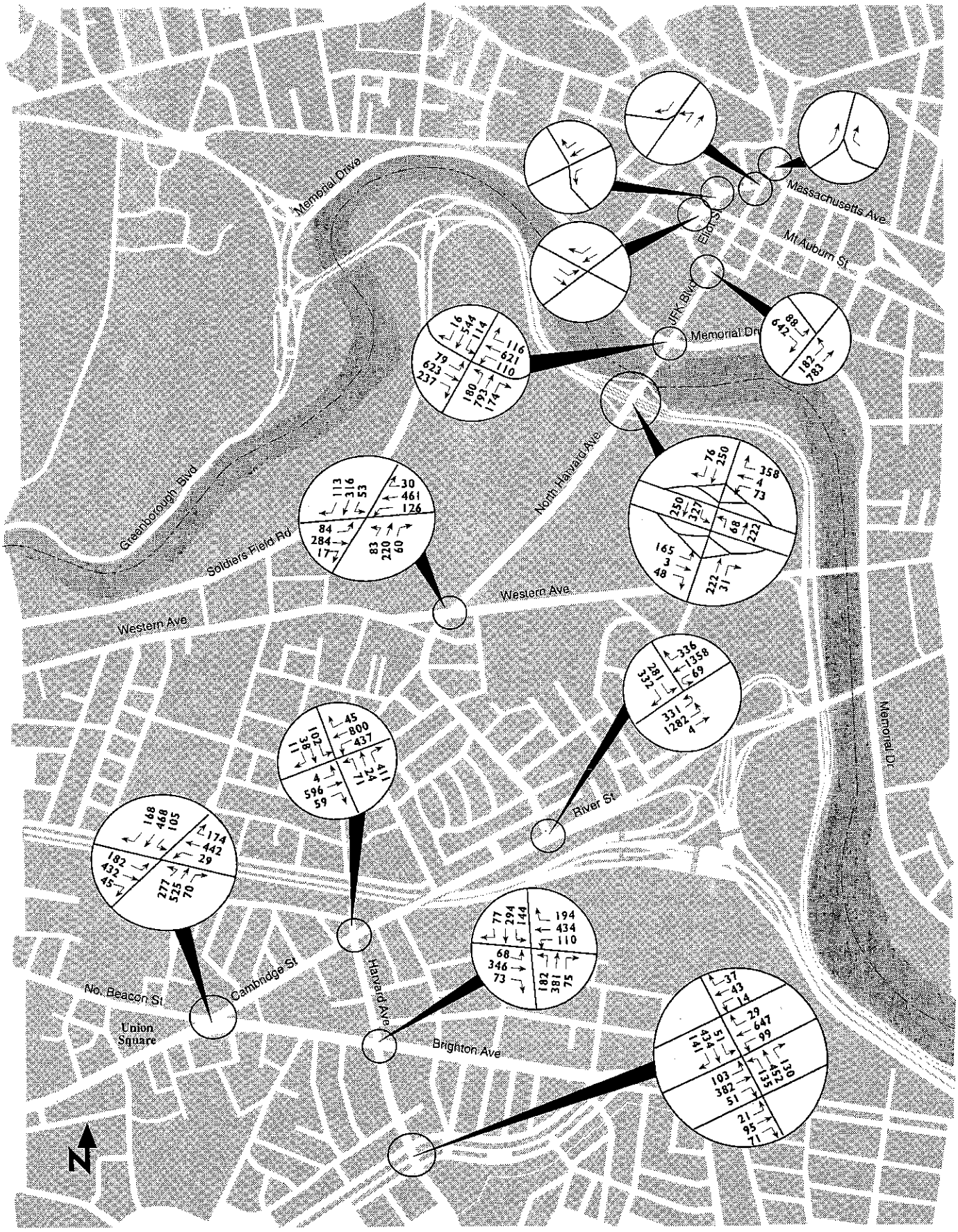


Figure 10
Turning Movement Volumes at Bus Route 66 Intersections in Cambridge & Allston/Brighton (P.M. Peak Hour, 1998)



B. Signal and Intersection Data, and Existing Signal Coordination Locations

Table 2 documents the cycle lengths and distance between signals for the analyzed intersections (which is important for signal coordination analysis). The cycle length information on the signalized intersections that are listed was available via either pre-existing traffic volume data (from signal permits) or collected data (signal timings in the field).

Signal permit data on record was obtained from the traffic engineers of the City of Boston, the Town of Brookline, the Metropolitan District Commission, the City of Cambridge, and MassHighway. The signal permits provide the cycle length and phase plan data needed for the HCM signalized intersection analysis. Signal timings were taken at actuated signals to measure the average duration of phases in order to replicate existing field conditions.

The HCM also requires lane geometry and left- or right-lane treatment data. CTPS collected this information for each intersection. In addition, staff took a series of photographs of each approach in order to document the lane geometry, the signage, and any problems observed in the field at the time.

Table 2. Signalized Intersections Included in the Analysis for Bus Route 66 (plus Cycle Length and Distance between Signals)

#	Intersection	Signal Cycle (sec) A.M.	Signal Cycle (sec) P.M.	Distance to Downstream Signal feet	Distance to Downstream Signal miles
Roxbury					
1	Dudley St/Warren St	110	90	528	0.10
2	New Dudley St/Washington St	100	90	158	0.03
3	New Dudley St/Shawmut Ave/Roxbury St	100	90	2640	0.50
5	Tremont St/New Dudley St/Columbus Ave	120	100	686	0.13
6	Tremont St/Parker St	100	100	1162	0.22
8	Tremont St/Saint Alphonsus St	80	90	1056	0.20
10	Huntington Ave/Tremont St	100	100	296	0.06
11	Huntington Ave/Fenwood St	60	60	1183	0.22
12	Huntington Ave/Parker Hill Ave	60	60	792	0.15
13	Huntington Ave/South Huntington Ave	128	143	528	0.10
Brookline					
16	Washington St/Brookline Ave	80	100	1056	0.20
17	Washington St/Boylston St/High St	80	100	686	0.13
19	Harvard St/Washington St/Davis St/Kent St	80	100	1214	0.23
21	Harvard St/Aspinwall St/School St	85	85	2482	0.47
30	Harvard St/Beacon St (Coolidge Corner)	110	110	739	0.14
31	Harvard St/Babcock St	90	110	528	0.10
32	Harvard St/Stedman St/Williams St	66	101	1056	0.20
33	Harvard St/Fuller St	74	76	1056	0.20
37	Harvard St/Verndale St (Pedestrian Signal)	60	60	1056	0.20
Allston/Brighton					
38	Harvard Ave/Commonwealth Ave	100	110	739	0.14
39	Harvard Ave/Brighton Ave	100	121	792	0.15
40	Brighton Ave/Allston St	100	100	792	0.15
42	Cambridge St/Brighton Ave/North Beacon St	100	110	1531	0.29
43	Cambridge St/Harvard Ave	109	110	1954	0.37
45	Cambridge St/North Harvard St	90	110	2482	0.47
50	North Harvard St/Western Ave	90	100	2429	0.46
Metropolitan District Commission					
51	North Harvard St/Soldiers Field Road	127	120	739	0.14
52	JFK Boulevard /Memorial Drive	129	131	729	0.14
Cambridge					
53	Eliot St/JFK Blvd	100	100	486	0.09
54	JFK Blvd /Mount Auburn St	100	100	475	0.09
55	JFK Blvd /Massachusetts Ave	100	100	739	0.14

Coordinated Signal Systems

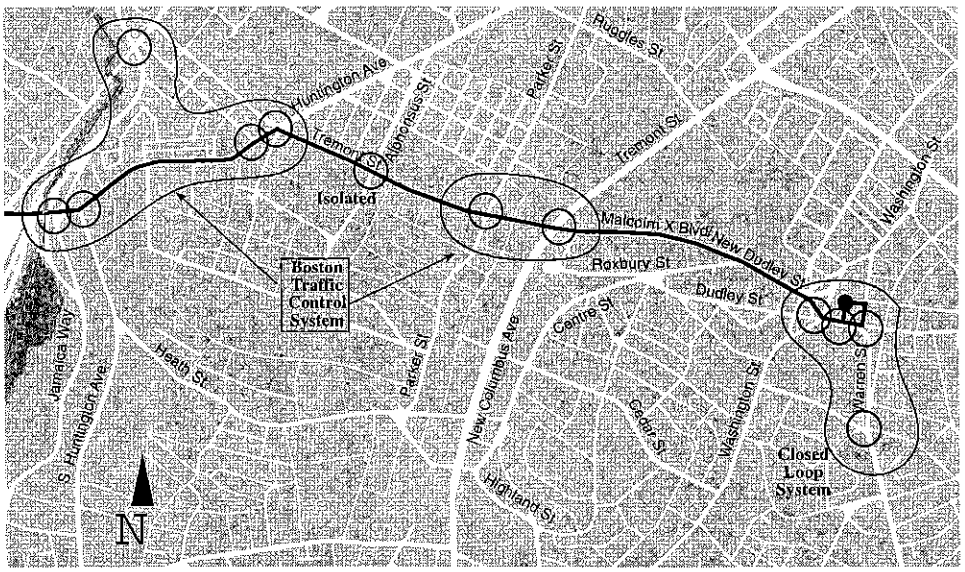
Numerous signals in the study area are part of coordinated signal systems. Some are a part of either a closed-loop system or a centralized traffic control grid. Boston and Cambridge have centralized traffic control systems. Brookline has both interconnected and time-based coordination systems. Most of the signals are semi-actuated, with fixed cycle lengths and coordination for the main street approaches.

Figures 11, 12, and 13 show the locations of the coordinated systems and the signals included in them. These are described in this section.

Roxbury

Roxbury has three coordinated systems in the study area (Figure 11). At Dudley Square, intersections with Dudley and Warren Streets are coordinated in a closed loop system. At Roxbury Crossing, the intersections of Tremont Street with Parker Street and New Dudley Street/Columbus Street are part of the Boston Traffic Department's central control grid. Here, coordination favors Tremont Street and Columbus Avenue. All of the signals on Huntington Avenue are part of the centralized control grid. The "E" branch of the Green Line runs in the street and the traffic control system gives priority to trolley operation. Traffic must stop when the trolleys stop, to protect boarding and alighting passengers.

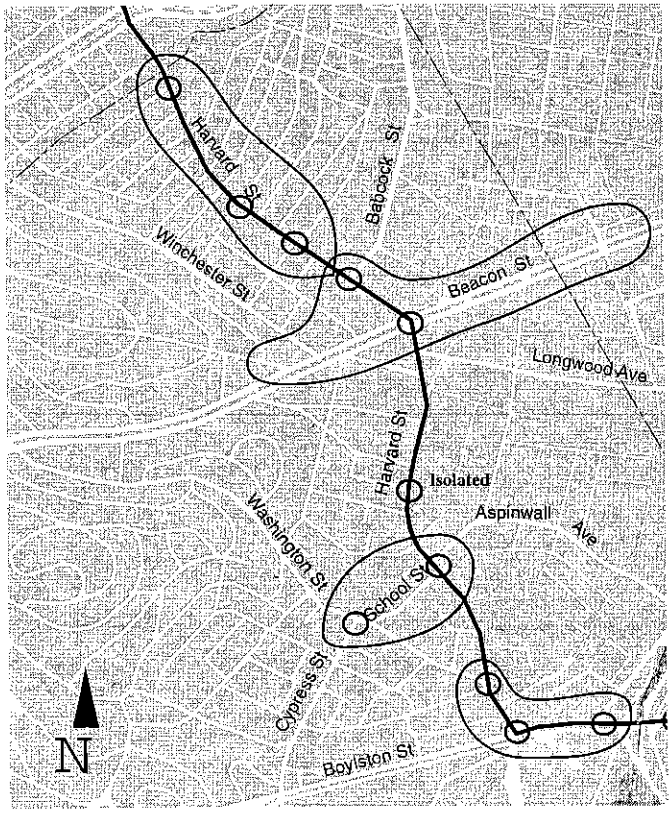
Figure 11. Signal Coordination at Intersections in Roxbury, Boston



Brookline

Brookline has four coordinated systems in the study area (Figure 12). Washington Street has an interconnected system that coordinates the signals at Brookline Avenue, Boylston, and High Streets, and at Washington and Harvard Street. The interconnect signal system at Aspinwall, School, and Harvard Streets favors School Street and coordinates with School Street at Washington Street. The Beacon Street interconnect coordination system treats Harvard Street as the minor approach. The signal at the intersection of Harvard Street and Babcock Street is included in this system.

Figure 12. Signal Coordination at Intersections in Brookline



Brookline recently installed three new signals on Harvard Street north of Beacon Street. The signals at Verndale, Fuller, and Stedman Streets are fully actuated. Originally set as time-based coordination, this operation is currently turned off. Each of the signals is outfitted with Opticom signal priority equipment with the capacity for assigning differential priority. At present the system is used for emergency vehicle preemption. One fire truck is equipped with an emitter, though the town is working on a grant to purchase more.

Brookline installed a fourth new Harvard Street signal south of Beacon Street, between Vernon Street and Harris Street, to control turning movements into and out of the driveway of Stop & Shop grocery store. The signal is fully actuated, operates in isolation, and is also outfitted with the Opticom equipment. It replaced the old pedestrian signal at Vernon Street. Though it is isolated, the Town of Brookline traffic department hopes to include it in a coordination system in the future.

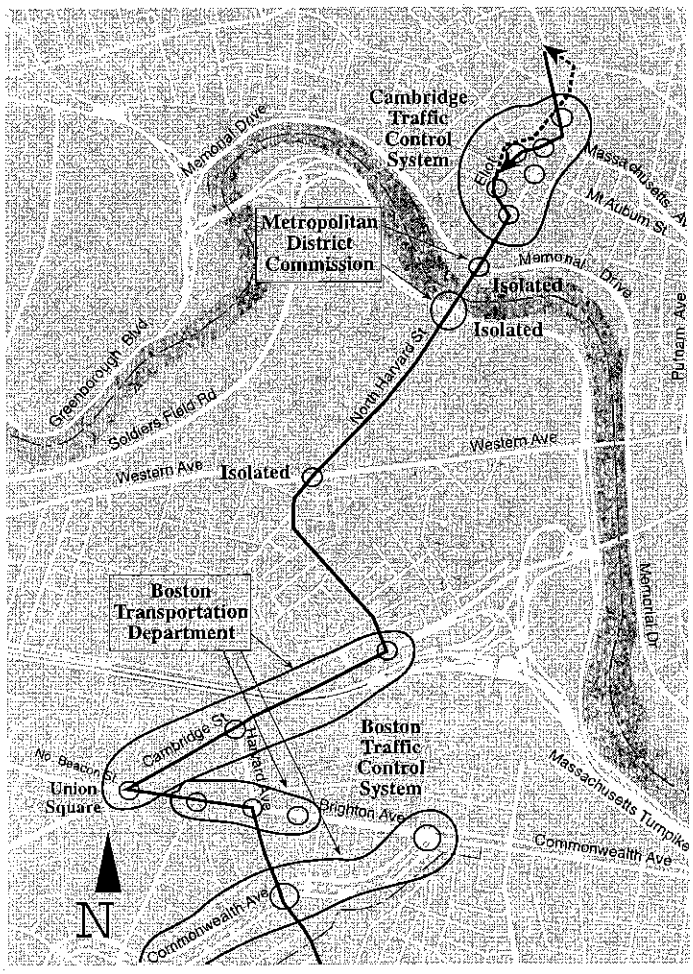
Allston/Brighton and Cambridge

Bus Route 66 buses travel past three coordinated systems in Allston/Brighton (Figure 13). Harvard Avenue at Commonwealth Avenue is the first system, with Harvard Avenue as the minor street. Harvard Avenue is also considered the minor street in the second system. Coordination of the second system favors Brighton Avenue from Linden Street to Everett Street, with the exception of Cambridge Street. Cambridge Street, from Brighton Avenue through North Harvard Avenue contains the third set of coordinated signals. Further north along the bus route, the intersection of Western Avenue with North Harvard Avenue has an isolated signal that is semi-actuated.

The Metropolitan District Commission (MDC) operates two isolated intersections on the bus route (shown in Figure 13). The first signal, North Harvard Avenue at Soldiers Field Road, operates as a semi-actuated signal with the non-actuated phase serving North Harvard Avenue. The second signal, John F. Kennedy Street at Memorial Drive, is a pre-timed signal with four-phase operation including an exclusive pedestrian phase.

Cambridge has interconnected most of the signals in Harvard Square. The signal are connected via an Eagle Comtrec system and share the same cycle lengths. As of the spring of 1998, John F. Kennedy Street at Eliot Street and Eliot Street at Bennett Street were not part of the system; instead, they operate as isolated, pre-timed signals. At John F. Kennedy Street and Eliot Street, pedestrian actuation shortens the available green time for the John F. Kennedy northbound approach and interrupts the "free rights" from Eliot Street to John F. Kennedy, terminating the green right arrow.

Figure 13. Signal Coordination at Intersections in Allston-Brighton and Cambridge



C. Level-of-Service Analysis

In the Summer of 1998, CTPS conducted two analyses of delay conditions: one used GPS-equipped vehicles to estimate travel time through the corridor (and to map the delay locations), the other used turning movement and signal timing data to estimate signalized intersection level-of-service based on the guidelines of the Highway Capacity Manual (described below). Table 3 shows the intersections for which either analysis found congested operations; a total of 26 intersections were identified as such. The table also compares the intersections with failing levels-of service with the list of problem intersections identified in the travel time study.

Table 3. Congested Intersections Along Bus Route 66

#	Description of the Intersection	Signal System	Problem Time Period					
			HCS			Travel Time Study		
			A.M.	Midday	P.M.	A.M.	Midday	P.M.
	Roxbury							
1	Dudley Street/Warren Street	Coordinated	•	•	•			•
2	New Dudley Street/Washington Street	Equipped for Coord.	•	•	•		•	•
5	Tremont Street/New Dudley Street/Columbus Avenue	BTCS	•		•	•	•	•
6	Tremont Street/Parker Street	BTCS			•			
8	Tremont Street/Saint Alphonsus Street	Isolated			•			
10	Huntington Avenue/Tremont Street	BTCS	•	•	•	•	•	•
13	Huntington Avenue/South Huntington Avenue	Isolated			•			•
	Brookline							
16	Washington Street/Brookline Avenue	Coordinated						•
17	Washington Street/Boylston Street/High Street	Coordinated	•	•	•	•		
19	Harvard Street/Washington Street/Davis Street/Kent Street	Coordinated	•		•		•	•
21	Harvard Street/Aspinwall Street/School Street	Coordinated	•	•	•	•	•	
30	Harvard Street/Beacon Street (Coolidge Corner)	Coordinated		•		•		•
31	Harvard Street/Babcock Street	Coordinated	•	•	•			
32	Harvard Street/Stedman Street/Williams Street	Coordinated						•
37	Harvard Street/Verndale Street (Pedestrian Signal)	Coordinated			•			
	Allston/Brighton							
38	Harvard Avenue/Commonwealth Avenue	BTCS			•		•	•
39	Harvard Avenue/Brighton Avenue	BTCS	•		•	•	•	•
40	Brighton Avenue/Allston Street	BTCS	•	•	•			
42	Cambridge Street/Brighton Avenue/North Beacon Street	BTCS	•	•	•		•	
43	Cambridge Street/Harvard Avenue	BTCS	•	•	•	•		•
45	Cambridge Street/North Harvard Street	BTCS	•	•	•	•		•
50	North Harvard Street/Western Avenue	Isolated	•	•	•	•	•	•
	Metropolitan District Commission							
51	North Harvard Street/Soldiers Field Road	Isolated	•	•	•	•		•
52	JFK Boulevard /Memorial Drive	Isolated, Pretimed	•	•	•	•		
	Cambridge							
53	Eliot Street/JFK Boulevard	CTCS				•	•	
54	JFK Boulevard /Mount Auburn Street	CTCS					•	

BTCS = Boston Traffic Control System

CTCS = Cambridge Traffic Control System

• denotes congestion

The level-of-service (LOS) analysis for this study utilized the methodology outlined in Chapter 9 of the Highway Capacity Manual. For signalized intersections, level-of-service is divided into six categories ranging from A to F. Each category is assigned a range of delay expressed in seconds, as shown in Table 4. These levels of service serve as a measure of driver discomfort and lost travel time. LOS E, for instance, signifies that the movement is at capacity, and LOS F indicates failure of the intersection and excessive delay. For this study, intersections with a level-of-service E or F for any of their movements were deemed to be congested.

Substandard operation of traffic signals can result in traffic delays exceeding one minute. If there are many signals with substandard operations along an arterial, the average intersection delays may accumulate in a "domino effect" for through traffic (e.g., buses) along the arterial. Delay to through traffic at intersections must, however, be balanced against the delay facing drivers on the cross streets.

Table 4. Level-of-Service Criteria for Signalized Intersections

Level of Service	Stopped Delay per Vehicle (seconds)
A	≤ 5
B	> 5 and ≤ 15
C	> 15 and ≤ 25
D	> 25 and ≤ 40
E	> 40 and ≤ 60
F	> 60

Comments and Observations

In general, capacity and delay problems are worst in the evening peak hour. Nearly all of the 31 intersections analyzed showed failing levels of service for at least one approach. By jurisdiction, intersections in Brighton seem to have significant congestion in all three time periods. The two MDC intersections are also at capacity throughout the day under current operations. In Brookline, the signals from Babcock Street south to Boylston Street are congested. In Roxbury, congestion is found at the intersections of Dudley Street with Washington Street and Warren Street.

D. Capacity Analysis

The capacity analysis produced estimates of the level-of-service for each lane group of each approach at an intersection. Tables 5 through 16 list the level-of-service characteristics for each lane group at selected intersections in the MBTA bus route corridor. The tables are organized by neighborhood and by peak hour: morning peak hour (7:45 to 8:45 a.m.), midday peak hour (12:15 to 1:15 p.m.), and evening peak hour (5:00 to 6:00 p.m.). The analysis includes estimates of queue lengths in feet and number of cars for each lane group. Approaches on which the buses travel are indicated by a boldface, italicized font. An asterisk (*) represents a case where the level-of-service could not be calculated because the volume to capacity ratio exceeds 1.2; in practical terms, such a ratio can not be attained since it would mean that traffic exceeding 100 percent of design volume was able to get through the intersection. However, these cases can serve as a surrogate for "extreme" delay. Listed below is a glossary of the terms in the table.

Glossary of terms used in Tables 5 through 16:

- **Lane Group** - Accounts for the existence of exclusive left or right turn lanes and/or defacto left turn lanes.
- **Delay (secs)** - Additional travel time experienced by a driver, passenger, or pedestrian beyond what would reasonably be desired for a given trip.
- **LOS** (Level-of-Service) - A qualitative measure describing operational conditions within a traffic stream, in terms of speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.
- **Avg. Queue (cars)** - Number of cars, on average, waiting to be served by the system.
- **95th% Queue (cars)** - Number of cars in the 95 percentile of queues that form at an intersection. A measure of worst case scenario.
- **Avg. Queue Length/Lane (ft)** - The average length, in feet, that the queue stretches back from a traffic signal.
- **95th% Queue Length/Lane (ft)** - The length, in feet, for the 95th percentile of queues that form at an intersection. A measure of worst case scenario.
- **Approach Delay (secs)** - Stopped-time delay at an intersection plus average time lost to deceleration to and acceleration from a stop.
- **Approach LOS** - A qualitative measure describing operational conditions for an approach to an intersection.
- **Bus Direction** - The inbound or outbound path of the bus relative to the approaches of the intersection.

[Text discussion continues on page 46, following the LOS tables.]

Table 5. Level-of-Service for Selected Route 66 Intersections in Roxbury (A.M. Peak Hour)

Route 66 approaches are in bold italic

	EB			WB		NB			SB		
Roxbury											
Loc # 1 - (E-W)Dudley Street	(N-S)Warren Street										
Lane Group	***L***	***LT***	R	TR		L	T	R			
Delay (secs)	***26***	***25.9***	5.1	69.1		29.3	47.7	8.5			
LOS	***D***	***D***	B	F		D	E	B			
Avg Queue (cars)	***14***	***15***	6	27		12	29	0			
95th% Queue (cars)	***24***	***25***	11	40		21	43	0			
Avg Queue Length/Lane (ft)	***359***	***199***	140	355		298	731	3			
95th% Queue Length/Lane (ft)	***600***	***330***	275	530		516	1081	7			
Approach Delay (secs)		***21.4***		69.1			40.4				
Approach LOS		***C***		F			E				
Bus Direction		***I***									
Loc # 2 - (E-W)New Dudley Street	(N-S)Washington Street										
Lane Group		***TR***		LT		L		R	L	T	***R***
Delay (secs)		***22.6***		45.4		14.1		20	15.9	14.8	***15***
LOS		***C***		E		B		C	C	B	***B***
Avg Queue (cars)		***89***		85		2		58	33	16	***15***
95th% Queue (cars)		***125***		119		5		81	48	26	***24***
Avg Queue Length/Lane (ft)		***1174***		1114		58		1446	823	399	***363***
95th% Queue Length/Lane (ft)		***1645***		1561		124		2035	1200	653	***605***
Approach Delay (secs)		***22.6***		45.4			19.8			15.4	
Approach LOS		***C***		E			C			C	
Bus Direction		***I***									***O***
Loc # 3 - (E-W)New Dudley	(N-S)Shawmut Ave										
Lane Group		***LTR***		***LTR***		L	TR		L	T	R
Delay (secs)		***13.3***		***15.4***		17.5	16.4		15.6	15.3	18.3
LOS		***B***		***C***		C	C		C	C	C
Avg Queue (cars)		***9***		***17***		5	4		2	2	6
95th% Queue (cars)		***16***		***28***		10	8		4	5	11
Avg Queue Length/Lane (ft)		***118***		***226***		124	101		41	58	146
95th% Queue Length/Lane (ft)		***215***		***365***		248	207		89	124	286
Approach Delay (secs)		***13.3***		***15.4***			17			17	
Approach LOS		***B***		***C***			C			C	
Bus Direction		***I***		***O***							
Loc # 5 - (E-W)Tremont/New Dudley	(N-S)Tremont/Columbus										
Lane Group		***LTR***		***LT***	R	L	TR		L	TR	
Delay (secs)		***30.6***		***34.4***	1.5	62.8	32.3		39.1	26.6	
LOS		***D***		***D***	A	F	D		D	D	
Avg Queue (cars)		***16***		***13***	4	10	43		5	20	
95th% Queue (cars)		***27***		***22***	7	18	61		9	32	
Avg Queue Length/Lane (ft)		***213***		***168***	88	247	390		116	188	
95th% Queue Length/Lane (ft)		***348***		***288***	182	444	556		233	293	
Approach Delay (secs)		***30.6***		***22.7***			36.5			28.5	
Approach LOS		***D***		***C***			D			D	
Bus Direction		***I***		***O***							
Loc # 6 - (E-W)Tremont	(N-S)Parker										
Lane Group		***LTR***		***LT***	R					LTR	
Delay (secs)		***9.4***		***4.4***	0					31.4	
LOS		***B***		***A***	A					D	
Avg Queue (cars)		***14***		***9***	0					5	
95th% Queue (cars)		***24***		***17***	0					11	
Avg Queue Length/Lane (ft)		***352***		***228***	0					136	
95th% Queue Length/Lane (ft)		***590***		***416***	0					268	
Approach Delay (secs)		***9.4***		***3.4***						31.4	
Approach LOS		***B***		***A***						D	
Bus Direction		***I***		***O***							

Table 5. Level-of-Service for Selected Route 66 Intersections in Roxbury (A.M. Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB		WB		NB		SB
Loc # 8 - (E-W)Tremont	(N-S)St Alphonsus						
Lane Group	***LTR***		***LTR***		LTR		LTR
Delay (secs)	***22.1***		***11.1***		21.6		23.6
LOS	***C***		***B***		C		C
Avg Queue (cars)	***12***		***10***		8		5
95th% Queue (cars)	***21***		***18***		15		11
Avg Queue Length/Lane (ft)	***311***		***243***		198		134
95th% Queue Length/Lane (ft)	***534***		***438***		370		265
Approach Delay (secs)	***22.1***		***11.1***		21.6		23.6
Approach LOS	***C***		***B***		C		C
Bus Direction	***I***		***O***				
Loc # 10 - (E-W)Huntington Ave	(N-S)Tremont/Francis						
Lane Group	***LTR***		LTR		***LTR***		LTR
Delay (secs)	***29.2***		22		***69***		*
LOS	***D***		C		***F***		*
Avg Queue (cars)	***34***		18		***22***		32
95th% Queue (cars)	***49***		29		***34***		46
Avg Queue Length/Lane (ft)	***443***		239		***548***		794
95th% Queue Length/Lane (ft)	***644***		381		***847***		1162
Approach Delay (secs)	***29.2***		22		***69***		*
Approach LOS	***D***		C		***F***		*
	I				***O***		
Loc # 11 - (E-W)Huntington Ave	(N-S)Fenwood						
Lane Group	***LT***		***TR***				LR
Delay (secs)	***3.7***		***0.8***				20.2
LOS	***A***		***A***				C
Avg Queue (cars)	***19***		***5***				3
95th% Queue (cars)	***30***		***9***				6
Avg Queue Length/Lane (ft)	***251***		***60***				76
95th% Queue Length/Lane (ft)	***397***		***121***				160
Approach Delay (secs)	***3.7***		***0.8***				20.2
Approach LOS	***A***		***A***				C
Bus Direction	***I***		***O***				
Loc # 12 - (E-W)Huntington Ave	(N-S)Parker Hill						
Lane Group	***TR***		***LT***		LR		
Delay (secs)	***3.5***		***2.8***		32.1		
LOS	***A***		***A***		D		
Avg Queue (cars)	***13***		***6***		6		
95th% Queue (cars)	***22***		***11***		12		
Avg Queue Length/Lane (ft)	***172***		***74***		154		
95th% Queue Length/Lane (ft)	***293***		***144***		298		
Approach Delay (secs)	***3.5***		***2.8***		32.1		
Approach LOS	***A***		***A***		D		
Bus Direction	***I***		***O***				
Loc # 13 - (E-W)Huntington Ave	(N-S)South Huntington						
Lane Group	***T***	R	L	***T***	L	R	
Delay (secs)	***33***	9.2	34.1	***22***	23.6	3.9	
LOS	***D***	B	D	***C***	C	A	
Avg Queue (cars)	***37***	9	5	***15***	9	5	
95th% Queue (cars)	***53***	16	11	***25***	17	9	
Avg Queue Length/Lane (ft)	***487***	219	71	***386***	122	113	
95th% Queue Length/Lane (ft)	***701***	401	140	***636***	221	227	
Approach Delay (secs)	***26.3***			***25.1***	13.7		
Approach LOS	***D***			***D***	B		
Bus Direction	***I***			***O***			

Table 6. Level-of-Service for Selected Route 66 Intersections in Brookline (A.M. Peak Hour)

Route 66 approaches are in bold italic

	EB			WB			NB			SB		
Brookline												
Loc # 16 - (E-W)Washington St	(N-S)Brookline											
Lane Group	L	***LTR***			***LTR***			LTR		L	LT	R
Delay (secs)	11.7	***9.6***			***28.9***			23		21.5	18.9	3.6
LOS	B	***B***			***D***			C		C	C	A
Avg Queue (cars)	8	***24***			***16***			2		14	3	4
95th% Queue (cars)	14	***36***			***26***			5		24	6	8
Avg Queue Length/Lane (ft)	190	***219***			***145***			53		350	67	100
95th% Queue Length/Lane (ft)	357	***333***			***238***			115		588	142	204
Approach Delay (secs)		***10.1***			***28.9***			23			10.4	
Approach LOS		***B***			***D***			C			B	
Bus Direction		***I***			***O***							
Loc # 17 - (E-W)Washington Boylston	(N-S)Washington High Sts											
Lane Group		TR			T	***R***		LT		***L***	TR	
Delay (secs)		31.3			12.3	***14***		19.1		***36***	56	
LOS		D			B	***B***		C		***D***	E	
Avg Queue (cars)		47			16	***8***		13		***15***	12	
95th% Queue (cars)		66			26	***16***		22		***25***	20	
Avg Queue Length/Lane (ft)		614			207	***111***		171		***201***	290	
95th% Queue Length/Lane (ft)		870			341	***205***		291		***332***	505	
Approach Delay (secs)		31.3			12.9			19.1			42.7	
Approach LOS		D			B			C			E	
Bus Direction						***O***				***I***		
Loc # 19 - (E-W)Washington	(N-S)Harvard Davis											
Lane Group		TR			LT	***R***		LTR			***LT***	
Delay (secs)		19.5			21.2	***8.6***		82			***8***	
LOS		C			C	***B***		F			***B***	
Avg Queue (cars)		7			6	***9***		10			***10***	
95th% Queue (cars)		14			11	***16***		18			***18***	
Avg Queue Length/Lane (ft)		96			146	***218***		246			***135***	
95th% Queue Length/Lane (ft)		181			285	***400***		442			***240***	
Approach Delay (secs)		19.5			12.9			82			***8***	
Approach LOS		C			B			F			***B***	
Bus Direction						***O***					***I***	
Loc # 21 - (E-W)Aspinwall/School	(N-S)Harvard											
Lane Group	L	TR		L	TR		L	***TR***		L	***TR***	
Delay (secs)	28.4	17.8		39	20.2		17.8	*		61	***33.3***	
LOS	D	C		D	C		C	*		F	***D***	
Avg Queue (cars)	20	11		3	8		1	***42***		15	***17***	
95th% Queue (cars)	32	19		7	14		1	***60***		24	***27***	
Avg Queue Length/Lane (ft)	510	271		83	190		15	***1042***		366	***418***	
95th% Queue Length/Lane (ft)	798	478		173	357		34	***1488***		609	***678***	
Approach Delay (secs)		20.9			24.4			*			***38.7***	
Approach LOS		C			C			*			***D***	
Bus Direction								***O***			***I***	
Loc # 30 - (E-W)Beacon St	(N-S)Harvard											
Lane Group		T	R		T	R		***T***	R		***T***	R
Delay (secs)		10.3	31.5		7.1	16.7		***35.4***	23.7		***23.4***	24.1
LOS		B	D		B	C		***D***	C		***C***	C
Avg Queue (cars)		36	8		13	4		***20***	3		***14***	3
95th% Queue (cars)		52	15		22	9		***31***	6		***24***	5
Avg Queue Length/Lane (ft)		475	198		171	105		***495***	71		***185***	64
95th% Queue Length/Lane (ft)		686	369		291	213		***778***	149		***311***	136
Approach Delay (secs)		13.1			8.9			***33.5***			***23.5***	
Approach LOS		B			B			***D***			***C***	
Bus Direction								***O***			***I***	

Table 6. Level-of-Service for Selected Route 66 Intersections in Brookline (A.M. Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB	WB	NB	SB
Loc # 31 - (E-W)Babcock St	(N-S)Harvard St			
Lane Group		LR	***TR***	***LT***
Delay (secs)		76.7	***20.8***	***10.6***
LOS		F	***C***	***B***
Avg Queue (cars)		10	***14***	***12***
95th% Queue (cars)		17	***24***	***20***
Avg Queue Length/Lane (ft)		242	***361***	***292***
95th% Queue Length/Lane (ft)		436	***602***	***509***
Approach Delay (secs)		76.7	***20.8***	***10.6***
Approach LOS		F	***C***	***B***
Bus Direction			***O***	***I***
Loc # 32 - (E-W)Stedman & Williams	(N-S)Harvard St			
Lane Group		LTR	***LT***	***TR***
Delay (secs)		12.6	***11***	***3.7***
LOS		B	***B***	***A***
Avg Queue (cars)		1	***11***	***33***
95th% Queue (cars)		1	***19***	***48***
Avg Queue Length/Lane (ft)		16	***271***	***827***
95th% Queue Length/Lane (ft)		35	***478***	***1205***
Approach Delay (secs)		12.6	***11***	***3.7***
Approach LOS		B	***B***	***A***
Bus Direction			***O***	***I***
Loc # 33 - (E-W)Fuller St	(N-S)Harvard St			
Lane Group	LTR	LTR	***LTR***	***LTR***
Delay (secs)	15.4	13.7	***5.2***	***13.7***
LOS	C	B	***B***	***B***
Avg Queue (cars)	2	1	***7***	***12***
95th% Queue (cars)	5	1	***13***	***21***
Avg Queue Length/Lane (ft)	60	16	***175***	***312***
95th% Queue Length/Lane (ft)	128	37	***334***	***535***
Approach Delay (secs)	15.4	13.7	***5.2***	***13.7***
Approach LOS	C	B	***B***	***B***
Bus Direction			***O***	***I***
Loc # 37 - (E-W)Verndale St	(N-S)Harvard St			
Lane Group	L R	L R	***TR***	***LT***
Delay (secs)	12.6 12.5	12.4 12.5	***4.9***	***3.1***
LOS	B B	B B	***A***	***A***
Avg Queue (cars)	0 0	0 0	***8***	***27***
95th% Queue (cars)	1 0	0 0	***15***	***41***
Avg Queue Length/Lane (ft)	8 5	1 4	***200***	***683***
95th% Queue Length/Lane (ft)	19 11	2 10	***372***	***1019***
Approach Delay (secs)	12.6	12.5	***4.9***	***3.1***
Approach LOS	B	B	***A***	***A***
Bus Direction			***O***	***I***

Table 7. Level-of-Service for Selected Route 66 Intersections in Allston-Brighton (A.M. Peak Hour)

Route 66 approaches are in bold italic

	EB			WB			NB		SB	
Allston/Brighton										
Loc # 38 - (E-W)Commonwealth Ave	(N-S)Harvard St									
Lane Group	L	T	R	L	T	R	***LTR***		***LTR***	
Delay (secs)	34.9	10.6	12	23.2	9.3	12.4	***24.6***		***22.7***	
LOS	D	B	B	C	B	B	***C***		***C***	
Avg Queue (cars)	7	19	1	1	9	2	***9***		***3***	
95th% Queue (cars)	13	30	2	2	16	3	***17***		***7***	
Avg Queue Length/Lane (ft)	86	245	11	14	113	21	***123***		***41***	
95th% Queue Length/Lane (ft)	165	390	24	31	209	46	***222***		***86***	
Approach Delay (secs)		14.8			10.8		***24.6***		***22.7***	
Approach LOS		B			B		***C***		***C***	
Bus Direction							***O***		***I***	
Loc # 39 - (E-W)Brighton Ave	(N-S)Harvard St									
Lane Group	L	***TR***		L	TR		***LTR***		LTR	
Delay (secs)	11.9	***16.2***		12.4	18.7		***25.4***		*	
LOS	B	***C***		B	C		***D***		*	
Avg Queue (cars)	1	***7***		9	14		***10***		51	
95th% Queue (cars)	2	***13***		16	24		***19***		73	
Avg Queue Length/Lane (ft)	27	***87***		225	189		***137***		1286	
95th% Queue Length/Lane (ft)	59	***167***		411	315		***244***		1816	
Approach Delay (secs)		***15.8***			17.5		***25.4***		*	
Approach LOS		***C***			C		***D***		*	
Bus Direction		***I***					***O***			
Loc # 40 - (E-W)Brighton Ave	(N-S)Allston Street									
Lane Group		***TR***			***LT***		L	R		
Delay (secs)		***1.4***			***1.6***		39.6	65.5		
LOS		***A***			***A***		D	F		
Avg Queue (cars)		***7***			***6***		4	5		
95th% Queue (cars)		***13***			***11***		9	10		
Avg Queue Length/Lane (ft)		***90***			***73***		105	132		
95th% Queue Length/Lane (ft)		***172***			***143***		214	262		
Approach Delay (secs)		***1.4***			***1.6***		52.3			
Approach LOS		***A***			***A***		E			
Bus Direction		***I***			***O***					
Loc # 42 - (E-W)Brighton Ave	(N-S)Cambridge St									
Lane Group		LTR		L	***LT***	R	LT	R		***LTR***
Delay (secs)		32.3		22.5	***24.1***	3.5	24.5	10.3		***13.5***
LOS		D		C	***C***	A	C	B		***B***
Avg Queue (cars)		18		2	***9***	0	15	4		***11***
95th% Queue (cars)		29		4	***17***	1	24	8		***19***
Avg Queue Length/Lane (ft)		235		51	***123***	7	193	96		***143***
95th% Queue Length/Lane (ft)		377		110	***223***	16	321	197		***252***
Approach Delay (secs)		32.3			***22.6***		20.7			***13.5***
Approach LOS		D			***C***		C			***B***
Bus Direction					***O***					***I***
Loc # 43 (E-W)Harvard St	(N-S)Cambridge St									
Lane Group		LTR			LT	R	***LT***	R	L	***TR***
Delay (secs)		24.6			23.8	17.2	***21.8***	17.2	*	***10.7***
LOS		C			C	C	***C***	C	*	***B***
Avg Queue (cars)		2			2	19	***21***	1	33	***13***
95th% Queue (cars)		5			3	30	***33***	2	49	***22***
Avg Queue Length/Lane (ft)		55			39	473	***280***	24	837	***167***
95th% Queue Length/Lane (ft)		117			86	750	***435***	53	1218	***286***
Approach Delay (secs)		24.6			40.5		***21.6***			*
Approach LOS		C			E		***C***			*
							O			***I***

Table 7. Level-of-Service for Selected Route 66 Intersections in Allston-Brighton (A.M. Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB		WB	NB		SB		
Loc # 45 - (E-W)North Harvard Street (N-S)Cambridge Street								
Lane Group	L	***R***		***L***	T	L	T	R
Delay (secs)	66.3	***15.5***		***100***	4.5	33	10.2	12.7
LOS	F	***C***		***F***	A	D	B	B
Avg Queue (cars)	20	***43***		***2***	53	15		7
95th% Queue (cars)	32	***61***		***4***	75	25		13
Avg Queue Length/Lane (ft)	505	***562***		***49***	695	387		172
95th% Queue Length/Lane (ft)	792	***802***		***106***	981	637		329
Approach Delay (secs)	***42.3***				19.7		11.7	
Approach LOS	***E***				C		B	
Bus Direction	***I***			***O***				
Loc # 50 - (E-W)Western Ave	(N-S)North Harvard St							
Lane Group	LTR		LTR	***LTR***		***LTR***		
Delay (secs)	*		*	*		*		
LOS	*		*	*		*		
Avg Queue (cars)	39		44	***38***		***44***		
95th% Queue (cars)	974		1106	***962***		***1098***		
Avg Queue Length/Lane (ft)	104		144	***223***		***274***		
95th% Queue Length/Lane (ft)	194		282	***408***		***482***		
Approach Delay (secs)	*		*	*		*		
Approach LOS	*		*	*		*		
Bus Direction				***O***		***I***		

Table 8. Level-of-Service for Selected Route 66 Intersections on MDC Roads and in Cambridge (A.M. Peak Hour)

Route 66 approaches are in bold italic

	EB		WB		NB		SB
Metropolitan District Commission							
Loc # 51 - (E-W)Soldiers Field Road	(N-S)North Harvard St						
Lane Group	L	TR	LT	R	***LTR***		***LTR***
Delay (secs)	*	28.5	30	21.9	*		***23.3***
LOS	*	D	D	C	*		***C***
Avg Queue (cars)	32	3	5	4	***57***		***36***
95th% Queue (cars)	47	6	10	9	***81***		***51***
Avg Queue Length/Lane (ft)	803	69	69	110	***1432***		***467***
95th% Queue Length/Lane (ft)	1174	145	137	222	***2015***		***676***
Approach Delay (secs)		*	26.2		*		***23.3***
Approach LOS		*	D		*		***C***
Bus Direction					***O***		***I***
Loc # 52 - (E-W)Memorial Drive	(N-S)JFK Boulevard						
Lane Group		LTR	DfL	TR	***LTR***		***LTR***
Delay (secs)		*	*	*	***32.7***		*
LOS		*	*	*	***D***		*
Avg Queue (cars)		191	8	88	***70***		***79***
95th% Queue (cars)		268	15	123	***99***		***111***
Avg Queue Length/Lane (ft)		2513	196	2191	***924***		***1041***
95th% Queue Length/Lane (ft)		3519	366	3069	***1296***		***1459***
Approach Delay (secs)		*		*	***32.7***		*
Approach LOS		*		*	***D***		*
Bus Direction					***O***		***I***
Cambridge							
Loc # 53 - (E-W)Eliot st	(N-S)JFK Boulevard						
Lane Group	L	***R***			***L***	T	
Delay (secs)	10.5	***0***			***9.4***	25	
LOS	B	***A***			***B***	C	
Avg Queue (cars)	1	***0***			***4***	23	
95th% Queue (cars)	2	***0***			***9***	35	
Avg Queue Length/Lane (ft)	22	***0***			***107***	565	
95th% Queue Length/Lane (ft)	48	***0***			***218***	869	
Approach Delay (secs)		***1.1***				20.8	
Approach LOS		***A***				C	
Bus Direction		***I***			***O***		
Loc # 54 - (E-W)Mount Auburn Street	(N-S)JFK Boulevard						
Lane Group		LT				TR	
Delay (secs)		23.1				21.9	
LOS		C				C	
Avg Queue (cars)		26				19	
95th% Queue (cars)		39				30	
Avg Queue Length/Lane (ft)		343				248	
95th% Queue Length/Lane (ft)		515				394	
Approach Delay (secs)		23.1				21.9	
Approach LOS		C				C	
Bus Direction							
Loc # 55 - (E-W)Brattle Street	(N-S)JFK Boulevard						
Lane Group					L	T	***R***
Delay (secs) d 2					0	0	***0.2***
Delay (secs)					0	0	***0.2***
LOS					A	A	***A***
Avg Queue (cars)					1	5	***14***
95th% Queue (cars)					2	10	***24***
Avg Queue Length/Lane (ft)					27	65	***188***
95th% Queue Length/Lane (ft)					60	129	***315***
Approach Delay (secs)						0	0.2
Approach LOS						A	A
Bus Direction							***I***

Table 9. Level-of-Service for Selected Route 66 Intersections in Roxbury (Midday Peak Hour)

Route 66 approaches are in bold italic

	EB			WB		NB			SB		
Roxbury											
Loc # 1 - (E-W)Dudley Street	(N-S)Warren Street										
Lane Group	***L***	***LT***	R	T	R	LTR					
v/c Ratio	***0.91***	***0.945***	1.094	0.589	0.246	0.66					
LOS	***E***	***D***	F	C	C	C					
Avg Queue (cars)	***12***	***8.5***	2	8	4.5	14					
95th% Queue (cars)	***21***	***16***	5	15	9	24					
Avg Queue Length/Lane (ft)	***300***	***111***	55	202	114	358					
95th% Queue Length/Lane (ft)	***520***	***205***	118	376	230	600					
Approach Delay (secs)		***53.7***		19		19.6					
Approach LOS		***E***		C		C					
Bus Direction		***I***									
Loc # 2 - (E-W)New Dudley Street	(N-S)Washington Street										
Lane Group		***TR***		LT		L		R	L	T	***R***
v/c Ratio		***0.376***		1.186		0.021		0.808	0.288	0.157	***0.2***
LOS		***B***		*		B		D	B	B	***B***
Avg Queue (cars)		***7.5***		23		0.1		6	3	1.5	***1.2***
95th% Queue (cars)		***14***		35		0.2		12	6	3	***2.6***
Avg Queue Length/Lane (ft)		***98***		301		2		157	74	38	***29***
95th% Queue Length/Lane (ft)		***185***		461		6		303	156	83	***65***
Approach Delay (secs)		***8.1***		*			25.8			7.5	
Approach LOS		***B***		*			D			B	
Bus Direction		***I***									***O***
Loc # 3 - (E-W)New Dudley	(N-S)Shawmut Ave										
Lane Group		***LT***	R	***LTR***		L	TR		L	T	R
v/c Ratio		***0.345***	0.059	***0.47***		0.407	0.144		0.408	0.124	0.693
LOS		***B***	B	***B***		C	B		C	B	C
Avg Queue (cars)		***5.6***	0.4	***8***		2	2		2	1	4
95th% Queue (cars)		***11.0***	1	***15***		5	4		4	2	8
Avg Queue Length/Lane (ft)		***73.2***	9	***102***		55	26		46	25	101
95th% Queue Length/Lane (ft)		***143.9***	20	***191***		117	55		101	55	206
Approach Delay (secs)		***11***		***11.8***			13.2			16.8	
Approach LOS		***B***		***B***			B			C	
Bus Direction		***I***		***O***							
Loc # 5 - (E-W)Tremont/New Dudley	(N-S)Tremont/Columbus										
Lane Group		***LTR***		***LT***	R	L	TR		L	TR	
v/c Ratio		***0.817***		***0.36***	0.285	0.632	0.776		0.728	0.912	
LOS		***C***		***B***	A	D	D		D	D	
Avg Queue (cars)		***24.97***		***14.9***	1	10	16		5	34	
95th% Queue (cars)		***37.763***		***24.8***	2	18	26		11	49	
Avg Queue Length/Lane (ft)		***327.73***		***196***	25	256	148		135	312	
95th% Queue Length/Lane (ft)		***495.64***		***325***	55	457	242		267	453	
Approach Delay (secs)		***22.7***		***8.9***			29.2			34.3	
Approach LOS		***C***		***B***			D			D	
Bus Direction		***I***		***O***							
Loc # 8 - (E-W)Tremont	(N-S)St Alphonsus										
Lane Group		***LTR***		***LTR***			LTR			LTR	
v/c Ratio		***0.715***		***0.88***			0.363			0.47	
LOS		***B***		***C***			B			B	
Avg Queue (cars)		***9***		***17***			3			4	
95th% Queue (cars)		***17***		***27***			7			8	
Avg Queue Length/Lane (ft)		***227***		***417***			78			92	
95th% Queue Length/Lane (ft)		***414***		***677***			164			189	
Approach Delay (secs)		***13.1***		***21.7***			10.9			12	
Approach LOS		***B***		***C***			B			B	
Bus Direction		***I***		***O***							

Table 9. Level-of-Service for Selected Route 66 Intersections in Roxbury (Midday Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB	WB	NB	SB
Loc # 10 - (E-W)Huntington Ave	(N-S)Tremont/Francis			
Lane Group	***LTR***	LTR	***LTR***	LTR
v/c Ratio	***0.845***	0.871	***0.94***	1.286
LOS	***C***	C	***D***	*
Avg Queue (cars)	***22***	21	***17***	22
95th% Queue (cars)	***34***	33	***27***	33
Avg Queue Length/Lane (ft)	***292***	275	***421***	539
95th% Queue Length/Lane (ft)	***449***	429	***683***	836
Approach Delay (secs)	***21.3***	23.2	***39.1***	*
Approach LOS	***C***	C	***D***	*
Bus Direction	***I***		***O***	

Table 10. Level-of-Service for Selected Route 66 Intersections in Brookline (Midday Peak Hour)

Route 66 approaches are in bold italic

	EB		WB		NB		SB	
Brookline								
Loc # 17 - (E-W)Washington Boylston	(N-S)Washington High Sts							
Lane Group	TR		T	***R***	LTR		***L***	TR
v/c Ratio	0.589		0.518	***0.309***	0.286		***0.943***	1.308
LOS	B		B	***B***	C		***E***	*
Avg Queue (cars)	156		138	***57***	42		***70***	***47***
95th% Queue (cars)	218		194	***80***	60		***98***	***67***
Avg Queue Length/Lane (ft)	2048		1815	***742***	553		***913***	***1179***
95th% Queue Length/Lane (ft)	2867		2541	***1045***	789		***1281***	***1671***
Approach Delay (secs)	10.4		10.7		19.8			*
Approach LOS	B		B		C			*
Bus Direction				***O***				***I***
Loc # 19 - (E-W)Washington	(N-S)Harvard Davis							
Lane Group	TR		LT	***R***	LTR		***L***	***T***	R
v/c Ratio	0.692		0.507	***0.525***	0.35		***0.06***	***0.557***	0.042
LOS	D		C	***B***	D		***B***	***B***	B
Avg Queue (cars)	41		37	***61***	10		***8***	***79***	4
95th% Queue (cars)	59		54	***85***	18		***16***	***111***	8
Avg Queue Length/Lane (ft)	1031		930	***1517***	260		***212***	***1977***	103
95th% Queue Length/Lane (ft)	1474		1340	***2132***	462		***392***	***2771***	211
Approach Delay (secs)	25.8		13.1		26.2			***9.9***	
Approach LOS	D		B		D			***B***	
Bus Direction				***O***				***I***	
Loc # 21 - (E-W)Aspinwall/School	(N-S)Harvard							
Lane Group	L	TR	L	TR	L	***TR***	L	***TR***
v/c Ratio	1.096	0.463	0.322	0.833	0.524	***1.07***	0.457	***0.893***
LOS	*	C	C	D	C	*	B	***D***
Avg Queue (cars)	20	5	2	9	1	***19***	4	***15***
95th% Queue (cars)	31	10	4	17	2	***30***	9	***25***
Avg Queue Length/Lane (ft)	490	121	40	237	27	***473***	105	***380***
95th% Queue Length/Lane (ft)	772	242	88	429	59	***750***	213	***628***
Approach Delay (secs)		*		26.5		*		***27.1***
Approach LOS		*		D		*		***D***
Bus Direction						***O***		***I***
Loc # 30 - (E-W)Beacon St	(N-S)Harvard							
Lane Group	T	R	T	R	***T***	R	***T***	R
v/c Ratio	0.567	1.044	0.673	1.024	***0.72***	0.413	***0.329***	0.457
LOS	B	F	B	F	***C***	C	***B***	C
Avg Queue (cars)	18	11	23	11	***15***	3	***8***	3
95th% Queue (cars)	29	20	35	19	***25***	5	***16***	5
Avg Queue Length/Lane (ft)	240	287	296	273	***371***	64	***111***	63
95th% Queue Length/Lane (ft)	383	502	455	481	***617***	136	***205***	134
Approach Delay (secs)	26.2		24.4		***16.8***		***13.4***	
Approach LOS	D		C		***C***		***B***	
Bus Direction					***O***		***I***	

Table 10. Level-of-Service for Selected Route 66 Intersections in Brookline (Midday Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB		WB		NB	SB
Loc # 31 - (E-W)Babcock St	(N-S)Harvard St					
Lane Group			LR		***TR***	***LT***
v/c Ratio			1.403		***0.8***	***0.595***
LOS			*		***C***	***B***
Avg Queue (cars)			21		***19***	***13***
95th% Queue (cars)			33		***30***	***22***
Avg Queue Length/Lane (ft)			524		***478***	***313***
95th% Queue Length/Lane (ft)			816		***756***	***538***
Approach Delay (secs)			*		***18.7***	***8.8***
Approach LOS			*		***C***	***B***
Bus Direction					***O***	***I***
Loc # 33 - (E-W)Fuller St	(N-S)Harvard St					
Lane Group	LTR		LTR		***LTR***	***LTR***
v/c Ratio	0.638		0.132		***0.72***	***0.485***
LOS	C		C		***B***	***B***
Avg Queue (cars)	3		-1		***10***	***28***
95th% Queue (cars)	7		-3		***18***	***41***
Avg Queue Length/Lane (ft)	84		-30		***248***	***695***
95th% Queue Length/Lane (ft)	174		-72		***445***	***1035***
Approach Delay (secs)	20.6		15.7		***5.6***	***5.7***
Approach LOS	C		C		***B***	***B***
Bus Direction					***O***	***I***
Loc # 37 - (E-W)Verndale St	(N-S)Harvard St					
Lane Group	L	R	L	R	***TR***	***LT***
v/c Ratio	0.082	0.059	0.059	0.088	***0.65***	***0.473***
LOS	B	B	B	B	***A***	***A***
Avg Queue (cars)	0	0	0	0	***6***	***28***
95th% Queue (cars)	1	0	1	1	***12***	***41***
Avg Queue Length/Lane (ft)	10	5	7	8	***158***	***690***
95th% Queue Length/Lane (ft)	24	11	17	17	***305***	***1028***
Approach Delay (secs)	14.8		14.8		***1.8***	***1***
Approach LOS	B		B		***A***	***A***
Bus Direction					***O***	***I***

Table 11. Level-of-Service for Selected Route 66 Intersections in Allston-Brighton (Midday Peak Hour)

Route 66 approaches are in bold italic

	EB			WB			NB			SB		
Allston/Brighton												
Loc # 38 - (E-W)Commonwealth Ave	(N-S)Harvard St											
Lane Group	L	T	R	L	T	R		***LTR***			***LTR***	
v/c Ratio	0.557	0.192	0.182	0.152	0.231	0.265		***0.69***			***0.359***	
LOS	C	B	B	C	B	B		***D***			***C***	
Avg Queue (cars)	3	5	1	1	6	2		***9***			***3***	
95th% Queue (cars)	7	10	3	2	12	5		***17***			***7***	
Avg Queue Length/Lane (ft)	43	64	18	10	78	27		***125***			***42***	
95th% Queue Length/Lane (ft)	89	127	39	23	152	59		***225***			***89***	
Approach Delay (secs)		12.2			9.6			***26.1***			***22.7***	
Approach LOS		B			B			***D***			***C***	
Bus Direction								***O***			***I***	
Loc # 40 - (E-W)Brighton Ave	(N-S)Allston Street											
Lane Group	***TR***				***LT***		L		R			
v/c Ratio	***0.304***				***0.44***		0.679		0.805			
LOS	***A***				***A***		D		E			
Avg Queue (cars)	***5***				***6***		4		4			
95th% Queue (cars)	***10***				***11***		7		8			
Avg Queue Length/Lane (ft)	***69***				***77***		88		99			
95th% Queue Length/Lane (ft)	***136***				***151***		183		203			
Approach Delay (secs)	***1.3***				***1.5***			40.7				
Approach LOS	***A***				***A***			E				
Bus Direction	***I***				***O***							
Loc # 42 - (E-W)Brighton Ave	(N-S)Cambridge St											
Lane Group	LTR			L	***LT***	R		LT	R		***LTR***	
v/c Ratio	0.959			0.589	***0.62***	0.123		0.79	0.319		***0.665***	
LOS	D			C	***C***	A		D	B		***C***	
Avg Queue (cars)	23			7	***14***	1		13	3		***20***	
95th% Queue (cars)	35			13	***23***	2		23	6		***32***	
Avg Queue Length/Lane (ft)	301			167	***183***	23		175	77		***264***	
95th% Queue Length/Lane (ft)	462			320	***307***	51		297	162		***414***	
Approach Delay (secs)	39.2				***21.9***			22.4			***15.1***	
Approach LOS	D				***C***			C			***C***	
Bus Direction					***O***						***I***	
Loc # 43 - (E-W)Harvard St	(N-S)Cambridge St											
Lane Group	LTR				LT	R		***LT***	R	L	***TR***	
v/c Ratio	0.606				0.544	0.65		***0.61***	0.207	1.008	***0.375***	
LOS	C				C	B		***C***	B	E	***B***	
Avg Queue (cars)	4				4	9		***16***	2	22	***12***	
95th% Queue (cars)	9				7	17		***27***	4	33	***21***	
Avg Queue Length/Lane (ft)	109				88	232		***214***	44	539	***161***	
95th% Queue Length/Lane (ft)	221				182	421		***349***	95	835	***278***	
Approach Delay (secs)	21.6				16.3			***16.9***			***23.9***	
Approach LOS	C				C			***C***			***C***	
Bus Direction								***O***			***I***	

Table 11. Level-of-Service for Selected Route 66 Intersections in Allston-Brighton (Midday Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB		WB	NB		SB	
Loc # 45 - (E-W)North Harvard Street (N-S)Cambridge Street							
Lane Group	L	***R***		***L***	TR	L	T
v/c Ratio	0.662	***0.65***		***1.04***	0.71	0.019	0.461
LOS	D	***C***		***F***	B	C	A
Avg Queue (cars)	6	***8***		***3***	26	0	16
95th% Queue (cars)	12	***15***		***7***	40	0	26
Avg Queue Length/Lane (ft)	157	***199***		***79***	347	4	208
95th% Queue Length/Lane (ft)	303	***371***		***166***	520	8	341
Approach Delay (secs)	***22.9***				***15.7***		2.3
Approach LOS	***C***				***C***		A
Bus Direction	***I***			***O***			
Loc # 50 - (E-W)Western Ave	(N-S)North Harvard St						
Lane Group	LTR		LTR		***LTR***		***LTR***
v/c Ratio	1.175		1.701		***1***		***1.367***
LOS	*		*		***F***		***
Avg Queue (cars)	25		78		***12***		***26***
95th% Queue (cars)	38		109		***21***		***39***
Avg Queue Length/Lane (ft)	625		1943		***311***		***657***
95th% Queue Length/Lane (ft)	945		2723		***534***		***986***
Approach Delay (secs)	*		*		***65***		***
Approach LOS	*		*		***F***		***
Bus Direction					***O***		***I***

Table 12. Level-of-Service for Selected Route 66 Intersections on MDC Roads and in Cambridge (Midday Peak Hour)

Route 66 approaches are in bold italic

	EB		WB			NB	SB	
Metropolitan District Commission								
Loc # 51 - (E-W)Soldiers Field Road	(N-S)North Harvard S							
Lane Group	L	LTR	L	LT	R	***LTR***	L	***TR***
v/c Ratio	0.345	0.55	0.167	0.17	1.744	***1.46***	0.991	***0.435***
Delay (secs)	28.4	30.9	27.9	27.9	*	*	47.9	***14.1***
LOS	D	D	D	D	*	*	E	***B***
Avg Queue (cars)	2	4	1	1	33	***27***	32	***7***
95th% Queue (cars)	5	7	2	2	48	***41***	46	***13***
Avg Queue Length/Lane (ft)	57	90	25	26	819	***678***	791	***169***
95th% Queue Length/Lane (ft)	123	187	56	58	1195	***1013***	1159	***324***
Approach Delay (secs)		29.9		*		*		***31.7***
Approach LOS		D		*		*		***D***
Bus Direction						***O***		***I***
Loc # 52 - (E-W)Memorial Drive	(N-S)JFK Boulevard							
Lane Group		LTR		LTR		***LTR***		***LTR***
v/c Ratio		1.608		1.628		***0.52***		***1.132***
LOS		*		*		***C***		*
Avg Queue (cars)		84		82		***18***		***34***
95th% Queue (cars)		118		115		***29***		***49***
Avg Queue Length/Lane (ft)		1103		1080		***239***		***441***
95th% Queue Length/Lane (ft)		1545		1514		***381***		***642***
Approach Delay (secs)		*		*		***17.6***		*
Approach LOS		*		*		***C***		*
Bus Direction						***O***		***I***
Cambridge								
Loc # 53 - (E-W)Eliot st	(N-S)JFK Boulevard							
Lane Group	L	***R***				***LT***		
v/c Ratio	0.206	***0.47***				***0.64***		
LOS	C	***A***				***C***		
Avg Queue (cars)	2	***7***				***21***		
95th% Queue (cars)	5	***13***				***33***		
Avg Queue Length/Lane (ft)	59	***163***				***275***		
95th% Queue Length/Lane (ft)	126	***313***				***428***		
Approach Delay (secs)		***5.2***				***16.4***		
Approach LOS		***B***				***C***		
Bus Direction		***I***				***O***		
Loc # 54 - (E-W)Mount Auburn Street	(N-S)JFK Boulevard							
Lane Group		LT				TR		
v/c Ratio		0.579				0.709		
LOS		C				C		
Avg Queue (cars)		26				19		
95th% Queue (cars)		39				30		
Avg Queue Length/Lane (ft)		343				248		
95th% Queue Length/Lane (ft)		515				394		
Approach Delay (secs)		18.1				20.1		
Approach LOS		C				C		
Bus Direction								
Loc # 55 - (E-W)Brattle Street	(N-S)JFK Boulevard							
Lane Group						L T		***R***
v/c Ratio						0.207 0.217		***0.41***
LOS						A A		***A***
Avg Queue (cars)						1 8		***8***
95th% Queue (cars)						3 15		***16***
Avg Queue Length/Lane (ft)						30 102		***111***
95th% Queue Length/Lane (ft)						67 191		***205***
Approach Delay (secs)						1.7	***3***	
Approach LOS						A	***A***	
Bus Direction							***I***	

Table 13. Level-of-Service for Selected Route 66 Intersections in Roxbury (P.M. Peak Hour)

Route 66 approaches are in bold italic

	EB			WB		NB			SB		
Roxbury											
Loc # 1 - (E-W)Dudley Street	(N-S)Warren Street										
Lane Group	***L***	***LT***	R	T	R		LTR				
Delay (secs)	***42.2***	***39.6***	76.6	19.6	16.8		19.6				
LOS	***E***	***D***	F	C	C		C				
Avg Queue (cars)	***12***	***16***	20	7	2		7				
95th% Queue (cars)	***21***	***26***	31	14	4		13				
Avg Queue Length/Lane (ft)	***305***	***210***	489	181	41		173				
95th% Queue Length/Lane (ft)	***526***	***343***	771	342	89		330				
Approach Delay (secs)		***53.6***		19			19.6				
Approach LOS		***E***		C			C				
Bus Direction		***I***									
Loc # 2 - (E-W)New Dudley Street	(N-S)Washington Street										
Lane Group		***TR***		LT		L		R	L	T	***R***
Delay (secs)		***13.9***		*		12.2		14.5	7.9	7.4	***7.2***
LOS		***B***		*		B		B	B	B	***B***
Avg Queue (cars)		***13***		36		0		4	5	3	***2***
95th% Queue (cars)		***23***		51		0		9	10	7	***3***
Avg Queue Length/Lane (ft)		***176***		467		4		106	124	86	***38***
95th% Queue Length/Lane (ft)		***298***		675		10		216	247	179	***84***
Approach Delay (secs)		***13.9***		*			14.4			7.6	
Approach LOS		***B***		*			B			B	
Bus Direction		***I***									***O***
Loc # 3 - (E-W)New Dudley	(N-S)Shawmut Ave										
Lane Group		***LT***	R	***TR***		L	TR		L	T	R
Delay (secs)		***12.6***	10.8	***13.3***		19	14		14.9	15.3	26.3
LOS		***B***	B	***B***		C	B		B	C	D
Avg Queue (cars)		***11***	1	***12***		4	3		3	5	10
95th% Queue (cars)		***19***	1	***20***		8	6		5	10	18
Avg Queue Length/Lane (ft)		***139***	15	***154***		93	34		64	120	259
95th% Queue Length/Lane (ft)		***247***	33	***268***		192	73		136	240	460
Approach Delay (secs)		***12.5***		***13.3***			16.6			20.7	
Approach LOS		***B***		***B***			C			C	
Bus Direction		***I***		***O***							
Loc # 5 - (E-W)Tremont/New Dudley	(N-S)Tremont/Columbus										
Lane Group		***LTR***		***LT***	R	L	TR		L	TR	
Delay (secs)		***40.5***		***52***	2.6	52.8	20.1		28.2	36.4	
LOS		***E***		***E***	A	E	C		D	D	
Avg Queue (cars)		***25***		***15***	1	10	16		5	34	
95th% Queue (cars)		***38***		***25***	2	18	26		11	49	
Avg Queue Length/Lane (ft)		***328***		***196***	25	256	148		135	312	
95th% Queue Length/Lane (ft)		***496***		***325***	55	457	242		267	453	
Approach Delay (secs)		***40.5***		***42.4***			29.2			35.4	
Approach LOS		***E***		***E***			D			D	
Bus Direction		***I***		***O***							
Loc # 6 - (E-W)Tremont	(N-S)Parker										
Lane Group		***LTR***		***LT***	R					LTR	
Delay (secs)		*		*	0					44.4	
LOS		*		*	A					E	
Avg Queue (cars)		***56***		***66***	0					17	
95th% Queue (cars)		***78***		***92***	0					27	
Avg Queue Length/Lane (ft)		***1388***		***1647***	0					416	
95th% Queue Length/Lane (ft)		***1955***		***2312***	0					676	
Approach Delay (secs)		*		*						44.4	
Approach LOS		*		*						E	
Bus Direction		***I***		***O***							

Table 13. Level-of-Service for Selected Route 66 Intersections in Roxbury (P.M. Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB		WB		NB		SB	
Loc # 8 - (E-W)Tremont	(N-S)St Alphonsus							
Lane Group	***LTR***		***LTR***		LTR		DfL	TR
Delay (secs)	***38.4***		*		21.5		22.3	17
LOS	***D***		*		C		C	C
Avg Queue (cars)	***12***		***24***		5		3	3
95th% Queue (cars)	***20***		***37***		9		7	7
Avg Queue Length/Lane (ft)	***293***		***601***		117		78	81
95th% Queue Length/Lane (ft)	***510***		***914***		234		164	169
Approach Delay (secs)	***38.4***		*		21.5			19.5
Approach LOS	***D***		*		C			C
Bus Direction	***I***		***O***					
Loc # 10 - (E-W)Huntington Ave	(N-S)Tremont/Francis							
Lane Group	***LTR***		LTR		***LTR***			LTR
Delay (secs)	*		*		***55.7***			23.6
LOS	*		*		***E***			C
Avg Queue (cars)	***42***		66		***21***			12
95th% Queue (cars)	***60***		92		***33***			21
Avg Queue Length/Lane (ft)	***556***		862		***525***			155
95th% Queue Length/Lane (ft)	***792***		1210		***817***			270
Approach Delay (secs)	*		*		***55.7***			23.6
Approach LOS	*		*		***E***			C
Bus Direction	***I***				***O***			
Loc # 11 - (E-W)Huntington Ave	(N-S)Fenwood							
Lane Group	***LT***		***TR***					LR
Delay (secs)	***1.8***		***0.3***					32.4
LOS	***A***		***A***					D
Avg Queue (cars)	***12***		***7***					4
95th% Queue (cars)	***21***		***14***					8
Avg Queue Length/Lane (ft)	***163***		***98***					103
95th% Queue Length/Lane (ft)	***280***		***184***					210
Approach Delay (secs)	***1.8***		***0.3***					32.4
Approach LOS	***A***		***A***					D
Bus Direction	***I***		***O***					
Loc # 12 - (E-W)Huntington Ave	(N-S)Parker Hill							
Lane Group	***TR***		***LT***		LR			
Delay (secs)	***1***		***17.1***		38.3			
LOS	***A***		***C***		D			
Avg Queue (cars)	***9***		***25***		6			
95th% Queue (cars)	***16***		***38***		12			
Avg Queue Length/Lane (ft)	***118***		***333***		155			
95th% Queue Length/Lane (ft)	***216***		***502***		301			
Approach Delay (secs)	***1***		***17.1***		38.3			
Approach LOS	***A***		***C***		D			
Bus Direction	***I***		***O***					
Loc # 13 - (E-W)Huntington Ave	(N-S)South Huntington							
Lane Group	***T***	R	L	***T***	L	R		
Delay (secs)	***28***	10.5	76	*	36.3	4.3		
LOS	***D***	B	F	*	D	A		
Avg Queue (cars)	***49***	14	31	***130***	23	8		
95th% Queue (cars)	***70***	24	46	***182***	35	15		
Avg Queue Length/Lane (ft)	***649***	362	413	***3244***	298	200		
95th% Queue Length/Lane (ft)	***918***	604	606	***4542***	458	373		
Approach Delay (secs)	***22.9***			*	22.3			
Approach LOS	***C***			*	C			
Bus Direction	***I***			***O***				

Table 14. Level-of-Service for Selected Route 66 Intersections in Brookline (P.M. Peak Hour)

Route 66 approaches are in bold italic

	EB			WB			NB		SB		
Brookline											
Loc # 16 - (E-W)Washington St	(N-S)Brookline										
Lane Group	L	***LTR***			***LTR***		LTR		L	LT	R
Delay (secs)	17.7	***16.3***			***36.1***		25.7		39.8	32.8	18.6
LOS	C	***C***			***D***		D		D	D	C
Avg Queue (cars)	8	***25***			***39***		1		51	12	26
95th% Queue (cars)	15	***38***			***55***		2		72	21	39
Avg Queue Length/Lane (ft)	198	***233***			***354***		25		1270	306	652
95th% Queue Length/Lane (ft)	369	***352***			***509***		56		1795	527	980
Approach Delay (secs)		***16.6***			***36.1***		25.7			27.4	
Approach LOS		***C***			***D***		D			D	
Bus Direction		***I***			***O***						
Loc # 17 - (E-W)Washington Boylston	(N-S)Washington High Sts										
Lane Group		TR			T	***R***	LTR		***L***	TR	
Delay (secs)		12.4			15.2	***26.9***	24.6		***30.8***	*	
LOS		B			C	***D***	C		***D***	*	
Avg Queue (cars)		21			32	***13***	7		***13***	24	
95th% Queue (cars)		33			47	***22***	13		***22***	36	
Avg Queue Length/Lane (ft)		275			424	***170***	88		***172***	590	
95th% Queue Length/Lane (ft)		428			620	***290***	169		***293***	900	
Approach Delay (secs)		12.4			18.7		24.6			*	
Approach LOS		B			C		C			*	
Bus Direction						***O***				***I***	
Loc # 19 - (E-W)Washington	(N-S)Harvard Davis										
Lane Group		TR			LT	***R***	TR		***L***	***T***	R
Delay (secs)		47.4			63.9	***11.3***	32.9		***8***	***10.8***	8
LOS		E			F	***B***	D		***B***	***B***	B
Avg Queue (cars)		13			14	***11***	2		***1***	***20***	1
95th% Queue (cars)		22			24	***19***	5		***2***	***32***	1
Avg Queue Length/Lane (ft)		325			352	***267***	55		***23***	***505***	13
95th% Queue Length/Lane (ft)		554			590	***473***	119		***51***	***791***	29
Approach Delay (secs)		47.4			31.4		32.9			***10.5***	
Approach LOS		E			D		D			***B***	
Bus Direction						***O***				***I***	
Loc # 21 - (E-W)Aspinwall/School	(N-S)Harvard										
Lane Group	L	TR		L	TR		***LTR***		***L***	***TR***	
Delay (secs)	*	16.3		29.5	52.6		*		***16***	*	
LOS	*	C		D	E		*		***C***	*	
Avg Queue (cars)	29	7		4	16		***23***		***7***	***30***	
95th% Queue (cars)	43	13		8	27		***36***		***13***	***44***	
Avg Queue Length/Lane (ft)	736	169		92	407		***308***		***164***	***753***	
95th% Queue Length/Lane (ft)	1087	323		190	664		***470***		***315***	***1110***	
Approach Delay (secs)		*			47.3		*			*	
Approach LOS		*			E		*			*	
Bus Direction							***O***			***I***	
Loc # 30 - (E-W)Beacon St	(N-S)Harvard										
Lane Group		T	R		T	R	***T***	R		***T***	R
Delay (secs)		7.3	17.6		9.1	18.3	***33.7***	22.3		***27.3***	36.4
LOS		B	C		B	C	***D***	C		***D***	D
Avg Queue (cars)		15	5		28	5	***19***	2		***24***	6
95th% Queue (cars)		26	9		42	10	***30***	4		***36***	11
Avg Queue Length/Lane (ft)		203	115		367	120	***481***	50		***313***	146
95th% Queue Length/Lane (ft)		335	231		546	241	***760***	108		***477***	285
Approach Delay (secs)		9.1			10.2		***32.3***			***28.9***	
Approach LOS		B			B		***D***			***D***	
Bus Direction							***O***			***I***	

Table 14. Level-of-Service for Selected Route 66 Intersections in Brookline (P.M. Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB	WB	NB	SB
Loc # 31 - (E-W)Babcock St	(N-S)Harvard St			
Lane Group		LR	***TR***	***LT***
Delay (secs)		76.7	***20.8***	***10.6***
LOS		F	***C***	***B***
Avg Queue (cars)		32	***15***	***63***
95th% Queue (cars)		47	***24***	***89***
Avg Queue Length/Lane (ft)		800	***367***	***1583***
95th% Queue Length/Lane (ft)		1169	***612***	***2224***
Approach Delay (secs)		76.7	***20.8***	***10.6***
Approach LOS		F	***C***	***B***
Bus Direction			***O***	***I***
Loc # 32 - (E-W)Stedman & Williams	(N-S)Harvard St			
Lane Group		LTR	***LT***	***TR***
Delay (secs)		27.9	*******	***3.8***
LOS		D	*******	***A***
Avg Queue (cars)		1	***42***	***9***
95th% Queue (cars)		2	***60***	***16***
Avg Queue Length/Lane (ft)		23	***1059***	***222***
95th% Queue Length/Lane (ft)		52	***1511***	***407***
Approach Delay (secs)		27.9	*******	***3.8***
Approach LOS		D	*******	***A***
Bus Direction			***O***	***I***
Loc # 33 - (E-W)Fuller St	(N-S)Harvard St			
Lane Group	LTR	LTR	***LTR***	***LTR***
Delay (secs)	28.5	19.2	***3.6***	***6.9***
LOS	D	C	***A***	***B***
Avg Queue (cars)	8	1	***12***	***11***
95th% Queue (cars)	15	3	***21***	***19***
Avg Queue Length/Lane (ft)	201	29	***303***	***268***
95th% Queue Length/Lane (ft)	375	63	***523***	***474***
Approach Delay (secs)	28.5	19.2	***3.6***	***6.9***
Approach LOS	D	C	***A***	***B***
Bus Direction			***O***	***I***
Loc # 37 - (E-W)Verndale St	(N-S)Harvard St			
Lane Group	L R	L R	***TR***	***LT***
Delay (secs)	12.5 12.6	12.5 13.6	***6***	*******
LOS	B B	B B	***B***	*******
Avg Queue (cars)	0 0	0 1	***9***	***36***
95th% Queue (cars)	-1 -1	1 3	***17***	***52***
Avg Queue Length/Lane (ft)	-6 -10	6 30	***235***	***900***
95th% Queue Length/Lane (ft)	-13 -22	15 66	***425***	***1301***
Approach Delay (secs)	12.6	13.4	***6***	*******
Approach LOS	B	B	***B***	*******
Bus Direction			***O***	***I***

Table 15. Level-of-Service for Selected Route 66 Intersections in Allston-Brighton (P.M. Peak Hour)

Route 66 approaches are in bold italic

	EB			WB			NB		SB	
Allston/Brighton										
Loc # 38 - (E-W)Commonwealth Ave	(N-S)Harvard St									
Lane Group	L	T	R	L	T	R	***LTR***		***LTR***	
Delay (secs)	26.7	11.8	14.5	23.9	12	16.2	***87.9***		***22.4***	
LOS	D	B	B	C	B	C	***F***		***C***	
Avg Queue (cars)	18	195	-15	2	11	4	***54***		***56***	
95th% Queue (cars)	29	274	-70	3	20	8	***76***		***79***	
Avg Queue Length/Lane (ft)	235	2566	-200	21	147	50	***710***		***740***	
95th% Queue Length/Lane (ft)	376	3592	-923	46	258	103	***1001***		***1043***	
Approach Delay (secs)		14.9			14		***87.9***		***22.4***	
Approach LOS		B			B		***F***		***C***	
Bus Direction							***O***		***I***	
Loc # 39 - (E-W)Brighton Ave	(N-S)Harvard S									
Lane Group	L	***TR***		L	TR		***LTR***		LTR	
Delay (secs)	14.6	***20.1***		16.4	20.3		***55.7***		*	
LOS	B	***C***		C	C		***E***		*	
Avg Queue (cars)	3	***18***		8	18		***24***		71	
95th% Queue (cars)	6	***29***		14	29		***36***		100	
Avg Queue Length/Lane (ft)	71	***237***		190	243		***314***		1780	
95th% Queue Length/Lane (ft)	150	***379***		357	387		***478***		2497	
Approach Delay (secs)		***19.5***			19.7		***55.7***		*	
Approach LOS		***C***			C		***E***		*	
Bus Direction		***I***					***O***			
Loc # 40 - (E-W)Brighton Ave	(N-S)Allston Street									
Lane Group		***TR***			***LT***		L	R		
Delay (secs)		***1.3***			***3.3***		52.2	40.4		
LOS		***A***			***A***		E	E		
Avg Queue (cars)		***6***			***13***		6	3		
95th% Queue (cars)		***12***			***23***		11	7		
Avg Queue Length/Lane (ft)		***80***			***174***		138	84		
95th% Queue Length/Lane (ft)		***156***			***296***		272	175		
Approach Delay (secs)		***1.3***			***3.3***		47.4			
Approach LOS		***A***			***A***		E			
Bus Direction		***I***			***O***					
Loc # 42 - (E-W)Brighton Ave	(N-S)Cambridge St									
Lane Group		LTR		L	LT	***R***	LT	R	***LTR***	
Delay (secs)		31.9		27.2	31.4	***4.7***	27.5	11.3	***17.9***	
LOS		D		D	D	***A***	D	B	***C***	
Avg Queue (cars)		21		5	19	***0.576***	14	3	***20***	
95th% Queue (cars)		33		9	30	***1.3***	24	7	***32***	
Avg Queue Length/Lane (ft)		279		113	245	***14.39***	187	85	***266***	
95th% Queue Length/Lane (ft)		433		228	390	***32.49***	313	176	***416***	
Approach Delay (secs)		31.9			29		23.3		***17.9***	
Approach LOS		D			D		C		***C***	
Bus Direction					O				***I***	
Loc # 43 - (E-W)Harvard St	(N-S)Cambridge St									
Lane Group		LTR			LT	R	***LT***	R	L	***TR***
Delay (secs)		31.4			26.6	31.8	***20.5***	17.3	*	***11.7***
LOS		D			D	D	***C***	C	*	***B***
Avg Queue (cars)		78	2	72	103		***20***	39		***7***
95th% Queue (cars)		109	4	101	144		***32***	56		***14***
Avg Queue Length/Lane (ft)		1950	48	1795	2564		***508***	981		***184***
95th% Queue Length/Lane (ft)		2733	103	2517	3591		***796***	1406		***347***
Approach Delay (secs)		31.4			30.8		***20.2***			*
Approach LOS		D			D		***C***			*
Bus Direction							***O***			***I***

Table 15. Level-of-Service for Selected Route 66 Intersections in Allston-Brighton (P.M. Peak Hour) (continued)

Route 66 approaches are in bold italic

	EB		WB	NB		SB		
Loc # 45 - (E-W)North Harvard Street (N-S)Cambridge Street								
Lane Group	L	***R***		***L***	T	L	T	R
Delay (secs)	*	***28.5***		*	2.3	41.3	9.8	7.9
LOS	*	***D***		*	A	E	B	B
Avg Queue (cars)	18	***11***		***15***	28	2	102	
95th% Queue (cars)	29	***19***		***25***	42	5	143	
Avg Queue Length/Lane (ft)	457	***277***		***372***	367	58	1337	
95th% Queue Length/Lane (ft)	729	***487***		***618***	546	125	1872	
Approach Delay (secs)	*			*		10		
Approach LOS	*			*		6 B		
Bus Direction	***I***			***O***				
Loc # 50 - (E-W)Western Ave	(N-S)North Harvard St							
Lane Group	LTR		LTR	***LTR***		***LTR***		
Delay (secs)	*		*	*		*		
LOS	*		*	*		*		
Avg Queue (cars)	49		126	***61***		***79***		
95th% Queue (cars)	70		177	***86***		***110***		
Avg Queue Length/Lane (ft)	1232		3159	***1524***		***1969***		
95th% Queue Length/Lane (ft)	1743		4423	***2142***		***2759***		
Approach Delay (secs)	*		*	*		*		
Approach LOS	*		*	*		*		
Bus Direction				***O***		***I***		

Table 16. Level-of-Service for Selected Route 66 Intersections on MDC Roads and in Cambridge (P.M. Peak Hour)

Route 66 approaches are in bold italic

	EB		WB			NB	SB	
Metropolitan District Commission								
Loc # 51 - (E-W)Soldiers Field Road	(N-S)North Harvard St							
Lane Group	L	TR	L	T	R	***LTR***	L	***TR***
Delay (secs)	*	14.7	28.4	25.2	*	*	*	***15.5***
LOS	*	B	D	D	*	*	*	***C***
Avg Queue (cars)	29	2	4	0	40	***52***	38	***12***
95th% Queue (cars)	43	5	9	1	57	***73***	55	***21***
Avg Queue Length/Lane (ft)	724	58	109	6	990	***1292***	958	***304***
95th% Queue Length/Lane (ft)	1072	124	220	13	1419	***1824***	1376	***525***
Approach Delay (secs)		*		*		*		*
Approach LOS		*		*		*		*
Bus Direction						***O***		***I***
Loc # 52 - (E-W)Memorial Drive	(N-S)JFK Boulevard							
Lane Group		LTR		LTR		***LTR***	DfL	***TR***
Delay (secs)		*		*		***47***	*	*
LOS		*		*		***.4 E***	*	*
Avg Queue (cars)		77		76		***52***	15	***52***
95th% Queue (cars)		108		107		***74***	24	***74***
Avg Queue Length/Lane (ft)		1014		1003		***687***	367	***1309***
95th% Queue Length/Lane (ft)		1422		1406		***970***	612	***1847***
Approach Delay (secs)		*		*		***47.4***		*
Approach LOS		*		*		***E***		*
Bus Direction						***O***		***I***
Cambridge								
Loc # 53 - (E-W)Eliot st	(N-S)JFK Boulevard							
Lane Group	L	***R***				***LT***		
Delay (secs)	16.2	***0.4***				***19.9***		
LOS	C	***A***				***C***		
Avg Queue (cars)	2	***9***				***30***		
95th% Queue (cars)	4	***17***				***44***		
Avg Queue Length/Lane (ft)	51	***232***				***394***		
95th% Queue Length/Lane (ft)	109	***422***				***580***		
Approach Delay (secs)		***2.3***				***19.9***		
Approach LOS		***A***				***C***		
Bus Direction		***I***				***O***		
Loc # 54 - (E-W)Mount Auburn Street	(N-S)JFK Boulevard							
Lane Group		LT				TR		
Delay (secs)		19.1				32.1		
LOS		C				D		
Avg Queue (cars)		17				29		
95th% Queue (cars)		28				43		
Avg Queue Length/Lane (ft)		223				379		
95th% Queue Length/Lane (ft)		361				561		
Approach Delay (secs)		19.1				32.1		
Approach LOS		C				D		
Bus Direction								
Loc # 55 - (E-W)Brattle Street	(N-S)JFK Boulevard							
Lane Group						L T		***R***
Delay (secs)						0 2.7		***0.1***
LOS						A A		***A***
Avg Queue (cars)						1 8		***8***
95th% Queue (cars)						3 15		***16***
Avg Queue Length/Lane (ft)						30 102		***111***
95th% Queue Length/Lane (ft)						67 191		***205***
Approach Delay (secs)						2.3	0.1	
Approach LOS						A	A	
Bus Direction								***I***

Following the level-of-service estimates based on the capacity analysis, the problem movements at each intersection were grouped by Route 66 approaches and opposing approaches, and by peak hour, as well. Problem movements (by direction, lane group, and time of day) at congested intersections are summarized in Table 17.

Listed below are the letter designations for the various lane groups:

T	=	Through movement	LTR	=	Left turn, Through, and Right turn
L	=	Left turn	R	=	Right turn
LT	=	Left turn and Through	TR	=	Through and Right turn
DfL	=	Defacto Left turn			

Comments and Observations

In several cases, the analysis using the Highway Capacity Software (HCS) did not reveal problems for traffic on Route 66 approaches. On the other hand, the GPS-equipped travel time study showed significant delays for these approaches, on average. This would indicate that the delays are attributed less to intersection operation and more to other conflicts, such as double-parking or heavy pedestrian activity. Potentially, the travel time study reveals problems more readily since the observations take place over several days. HCS analysis, though, is based on observation of turning movements from one day, which may or may not have been representative of typical conditions. In addition, the travel time study illustrates the effects of traffic queues spilling back from intersections downstream. The HCS analysis cannot model the traffic delays resulting from nearby intersections—it can only model the static picture of an isolated intersection.

Problems for Route 66 approaches appear worst during the evening peak hour from 5:00 to 6:00 p.m. However, problems for opposing approaches are prevalent throughout the day. Three intersections showed significant problems in all three peak hours in both the HCS analysis and the travel time study: Huntington Avenue at Tremont Street, North Harvard Street at Western Avenue, and John F. Kennedy Street at Memorial Drive). In each case, delays are due to traffic conflicts resulting from commercial activity and parking conflicts as well as signal operation.

Table 17. Problem Lane Groups at Congested Intersections by Approach (for Route 66 and Opposing Approaches)

		Problem Time Period					
		Route 66 Approaches			Opposing Approaches		
#	Intersection	A.M.	Midday	P.M.	A.M.	Midday	P.M.
	Roxbury						
1	Dudley Street/Warren Street		EB L LT R	EB L T R	WB TR, NB T		
2	New Dudley Street/Washington Street				WB TR	WB LT	WB LT
5	Tremont Street/New Dudley Street/Columbus Avenue	**	**	EB LTR, WB LT	NB L		NB L
6	Tremont Street/Parker Street			EB LTR, WB LT			SB LTR
8	Tremont Street/Saint Alphonsus Street			WB LTR			
10	Huntington Avenue/Tremont Street	NB LTR	**	EB LTR, NB LTR	SB LTR	SB LTR	WB LTR
13	Huntington Avenue/South Huntington Avenue			WB L T			
	Brookline						
16	Washington Street/Brookline Avenue			**			
17	Washington Street/Boylston Street/High Street	**	SB L		SB TR†	SB TR†	SB TR†
19	Harvard Street/Washington Street/Davis Street/Kent Street				NB LTR		EB TR, WB LT
21	Harvard Street/Aspinwall Street/School Street	NB TR, SB L TR	NB TR	NB LTR, SB TR		EB L	EB L, WB TR
30	Harvard Street/Beacon Street (Coolidge Corner)	**		**		EB R, WB R	
31	Harvard Street/Babcock Street				WB LR	WB LR	WB LR
32	Harvard Street/Stedman Street/Williams Street			**			
37	Harvard Street/Verndale Street (Pedestrian Signal)			SB LT			

* No Midday HCS Analysis Available: Travel Time Study Showed problems for Route 66 Approaches

** Travel Time Study Showed problems for Route 66 Approaches

† The southbound approach is route 66 on the left turns

Table 17. Problem Lane Groups at Congested Intersections by Approach (for Route 66 and Opposing Approaches) (continued)

		Problem Time Period					
		Route 66 Approaches			Opposing Approaches		
#	Intersection	A.M.	Midday	P.M.	A.M.	Midday	P.M.
	Allston/Brighton						
38	Harvard Avenue/Commonwealth Avenue*		**	NB LTR		*	
39	Harvard Avenue/Brighton Avenue*	**	*	NB LTR, SB LTR	SB LTR	*	
40	Brighton Avenue/Allston Street				NB LR	NB R	NB L R
42	Cambridge Street/Brighton Avenue/North Beacon Street		WB LTR, SB L	WB LTR, SB L	NB LT	EB LTR, NB LT, SB TR	NB LT, SB TR†
43	Cambridge Street/Harvard Avenue	**	SB L		WB L, NB R	WB L	SB L
45	Cambridge Street/North Harvard Street	NB L	NB L	NB L	EB L		EB L, SB L
50	North Harvard Street/Western Avenue	NB LTR, SB LTR	NB LTR, SB LTR	NB LTR, SB LTR	EB LTR, WB LTR	EB LTR, WB LTR	EB LTR, WB LTR
	Metropolitan District Commission						
51	North Harvard Street/Soldiers Field Road	NB LTR	NB LTR	NB LTR, SB LTR	EB L		EB L TR, WB L TR
52	JFK Boulevard /Memorial Drive	SB LTR	SB LTR	NB LTR, SB DfL TR	EB LTR, WB DfL TR	EB LTR, WB LTR	EB L TR, WB LTR
	Cambridge						
53	Eliot Street/JFK Boulevard	**	**		**	**	
54	JFK Boulevard /Mount Auburn Street		**			**	

* No Midday HCS Analysis Available: Travel Time Study Showed problems for Route 66 Approaches

** Travel Time Study Showed problems for Route 66 Approaches

† The southbound approach is route 66 on the left turns

E. Traffic Queuing Impacts

In addition to the capacity analysis, CTPS staff analyzed the queuing behavior at the intersections. The analysis is based on MassHighway's Standard Queuing Analysis Spreadsheet (Version 2.0, May 14, 1996).[2] The length of the maximum back of the queue depends on the signal timing, vehicle arrival patterns, and the saturation rate. A set of equations in the spreadsheet calculates the average and 95th percentile queue length in feet and number of cars for each approach by lane group, using "Saturation Flow" and "Capacity" values output from the signalized intersection capacity analysis generated by the HCS. Vehicle spacing was assumed to be the MassHighway standard of 25 feet (7.62 meters). Refer to the tables in the previous section to view the queuing by approach for each intersection, by time period.

Comments and Observations

Lengthy queuing occurs at most of the intersections in all three time periods. In some cases, the queue length exceeds the distance to the upstream signal. This is due to either traffic volumes that exceed capacity or a signal phase plan that does not fit the traffic volume pattern. The queue from the downstream signal, consequently, contributes to failure at the upstream signal. Thus, excessively long queues compound the LOS problems already present at the upstream signals.

Eleven intersections had average queue lengths on Route 66 approaches that exceeded the distance to the upstream signal at some point during the day. Table 18 lists these intersections and the time of day the queues tended to occur, for both the inbound and the outbound bus paths. However, the queuing problems presented in Table 18 are not an indicator of the worst problems at the intersection where they occur: they only point out the significance of the distance between signals when traffic operations fail.

[2] This queuing analysis procedure uses the Australian Queuing Method developed by Rahmi Akcelik, formerly of the Australian Road Research Board (ARRB). Akcelik's method measures the queue extension at traffic signals, accounting for start-up delay at the start of a green phase. When the wave of start up vehicles leaving the stop line meets the stopping wave of vehicles arriving at the queue, the maximum back of queue is reached and no additional vehicles are required to stop.

Table 18. Signalized Intersections with Average Queue Lengths Exceeding the Distance between Traffic Signals

#	Queue from Intersection through Intersection	A.M. Peak Period		Midday Period		P.M. Peak Period	
		In	Out	In	Out	In	Out
2	New Dudley St. at Washington St. to New Dudley St. at Shawmut Ave.	•					
3	New Dudley St. at Shawmut Ave. to New Dudley at Washington St.		•				
5	Tremont St./New Dudley St./Columbus Ave. to Tremont St. at Parker St.					•	
6	Tremont St. at Parker St. to Tremont St./New Dudley St./Columbus Ave.						•
10	Huntington Ave. at Tremont St. to Huntington Ave. at Fenwood Ave	•					
17	Washington St. at Boylston St./High St. to Washington St. at Harvard St.			•			
19	Harvard St./Washington St./Davis St./Kent St. to Washington St./Boylston St./High St.				•		
30	Harvard St. at Beacon St. (Coolidge Corner) to Harvard St. at Babcock St.					•	
39	Harvard Ave at Brighton Ave to Harvard Ave at Cambridge St.*	•				•	
40	Brighton Ave. at Allston St. to Brighton Ave. at Cambridge St.			•			
51	North Harvard St. at Soldiers Field Rd. to JFK St. at Memorial Drive	•				•	
52	JFK St. at Memorial Drive to Eliot St. and to North Harvard St. at Soldiers Field Rd.	•	•				

* This queue is not directly on the route but it affects intersections that are.

In = inbound direction
Out = outbound direction

Appendix F:

Strategies to Alleviate Parking-Related Congestion (Technical Memorandum)

MEMORANDUM

TO: Mark Berger, MassHighway-BTP&D
David Carney, MBTA Service Planning

May 28, 1999

FROM: Amanda Amory

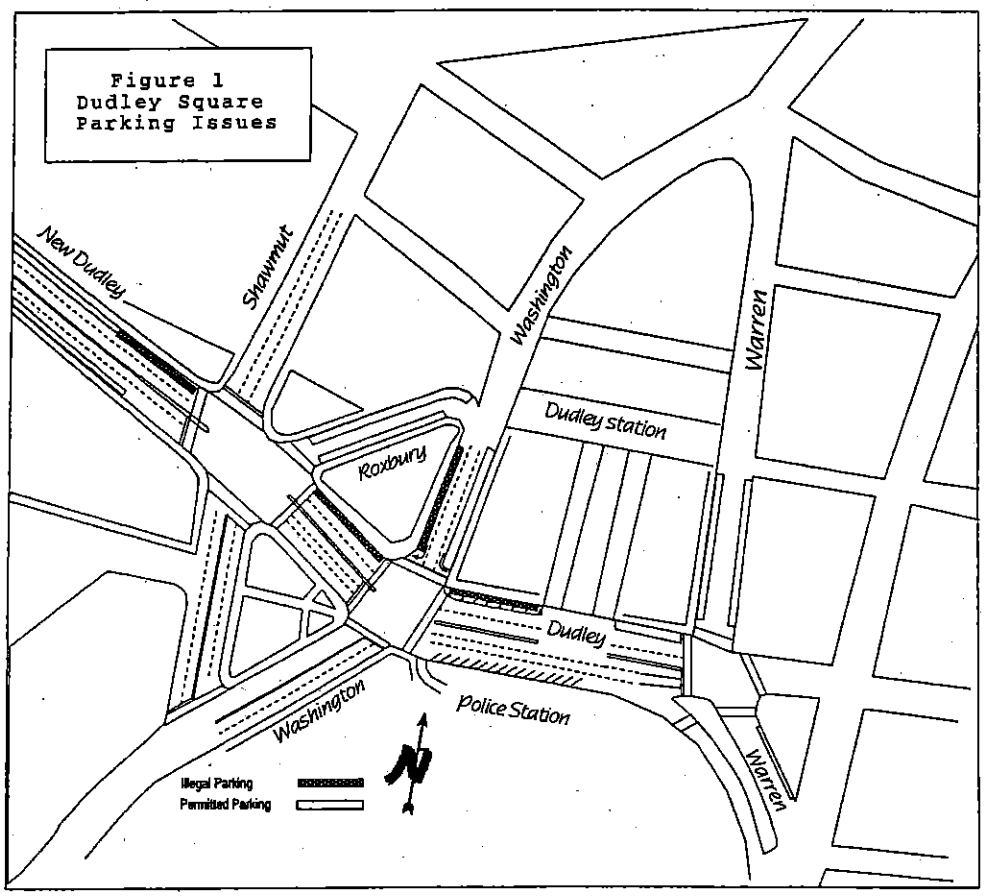
RE: MBTA Bus Route 66 Arterial Improvement Study: Strategies to Alleviate Parking-Related Congestion

Parked cars are prevalent on both sides of the street throughout most of the bus route, giving the impression that parking is permitted everywhere, including in bus stops. The extensive demand for on-street parking creates impedances in traffic flow and pedestrian access to the buses. Since the supply of parking spaces is limited, drivers often double-park to run errands or load and unload vehicles. Cars routinely park in the bus stops, forcing the buses to stop in the travel lanes while passengers board or alight. The double-parking causes traffic to queue up, leading to long traffic delays, and causing failures in on-time performance for the buses. Several segments of the route suffer from poorly marked or inconsistent parking restrictions. Only two commercial loading zones were identified along the route, neither of which was located where the commercial vehicles double-park. The existing parking conditions along the route are described below, by segment , with suggestions for improvement strategies to reduce the parking conflicts.

ROXBURY

Dudley Square

Parking issues affect traffic and bus service on four streets that come together in Dudley Square: Dudley, Warren, Washington, and New Dudley streets. On-street parking occurs on all of these streets, and on both sides of one-way streets. Spaces are undefined, and people park wherever they can, often disregarding parking restrictions. Buses must navigate around cars parked in travel lanes or encroaching on travel lanes, or parked in bus stops. Figure 1 illustrates the Dudley Square area and shows where the illegal parking occurs. Given the prevalence of on-street parking and the disregard for parking restrictions, it seems evident that a study of the demand for a parking facility in the area would be a good priority. Reducing the demand for on-street parking would reduce congestion throughout the Dudley Square/Dudley Station area.



Suggested Improvement Strategies:

- Look for an appropriate location to site an off-street parking facility.

Warren and Dudley Street

On Dudley Street, on-street parking with a two-hour limit is permitted on the westbound side of the street west of the intersection with Warren Street, for about 120 feet. On the east-bound side of the same block, the police station has angled parking facing into the street for about 20 cars. The parking is angled away from the direction of traffic flow, as vehicles are intended to park tail-end to the curb. Vehicles leaving from these spaces can enter the traffic stream at any point along the segment. The frequent parking maneuvers may contribute to the delay experienced along this stretch of Dudley Street. Warren Street is one-way at the intersection with Dudley Street. On Warren Street approaching the intersection (one-way from the south), parking is permitted on the right side of the road, but spaces are not marked or metered. On Warren Street north of the intersection, parking is permitted on both sides of the street, again without markings or meters.

Suggested Improvement Strategies:

- Install parking meters and stripe the spaces on Warren Street both approaching Dudley Street and north of the intersection. On Dudley Street westbound, west of the intersection, install parking meters and stripe the spaces in front of *A Nubian Notion*. Consider eliminating these spaces to facilitate traffic flow. The angled parking on the eastbound side seems to be necessary, as it serves police cruisers.

Dudley at Washington Street and Shawmut Avenue

The intersection of Dudley Street at Washington Street suffers from high volumes of westbound left turns to Washington Street southbound. The traffic forms queues in the shared left-and-through lane that extend back to Warren Street. Dudley Street westbound at Washington Street has striping and signage marking the curbside fronting BankBoston as a tow zone with "No Stopping Any Time." People park there continually, however. The through movement on Dudley Street westbound bends to the right across the intersection. Parked cars on the right side of New Dudley Street westbound block through movements leaving the intersection, making it necessary for cars on Dudley Street to merge into one lane for a short distance. Signage indicates that stopping is not permitted, yet there are always cars there.

Suggested Improvement Strategies:

- Restripe the westbound approach to Dudley Street to remove the striped no-parking zone and provide for a through lane. Paint a through arrow in the lane.
- Enforce the "No Stopping" restriction both approaching, and leaving the intersection of Dudley Street at Washington Street, to improve the traffic flow at the intersection.

Washington Street is one-way approaching the intersection southbound. Vehicles from both Roxbury Street and Dudley Station must merge with the traffic on Washington Street. On the approach to Dudley Street, cars park on both sides of the street; however, signage and striping clearly indicate that the right lane is a travel lane, not a parking lane, and that cars in the right lane must turn right. The right curb of Washington Street has multiple "No Stopping Anytime" signs; yet a sign posted in the middle of this segment permits two-hour parking over an unspecified distance.

Suggested Improvement Strategies:

- Remove the inconsistent parking signage and commit to the no parking policy on this segment of Washington Street, to facilitate the flow of traffic through the Washington Street and Dudley Street intersection.
- Enforce the parking restriction to keep people from parking in the travel lane and blocking traffic.

New Dudley Street from Shawmut Avenue to Tremont Street

On the westbound side of New Dudley Street from Shawmut Avenue to Tremont Street, signage indicates that parking is not permitted; however, cars are routinely parked there. Eastbound, parking is unrestricted, except for street cleaning periods and bus stops. A "Right-Turn-Only" lane approaching Roxbury Street is defined only by signage. The road is not striped for a right turn lane and nothing differentiates the lane from what is treated as the parking lane. Pavement on New Dudley Street is deteriorating and the markings have almost completely worn away.

Suggested Improvement Strategies:

- Stripe the eastbound side of New Dudley Street to clearly indicate where parking is permitted and where the right-turn-only lane is located.
- Enforce the parking restrictions on New Dudley Street.
- Repair and repaint New Dudley Street, providing for parking lanes in each direction.

Several closely spaced MBTA bus stops located along this segment are routinely blocked by parked cars. The distance between these bus stops is overly short and causes competing demand for curbside space. The segment of New Dudley Street in front of Madison Park Technical Vocational High School is reserved for school buses, on both sides of the street. MBTA bus stops are interlaced with the school bus zone. Although signage is present, the volume of signs along this stretch of New Dudley Street governing conflicting policies leaves a confusing impression. When school lets out, pedestrian activity is quite extensive as kids board the buses for home. Delay to traffic flow results from kids crossing the street. Further delays result from buses being double-parked alongside New Dudley Street waiting for students to be released from school.

Suggested Improvement Strategies:

- Consider reducing the number of MBTA bus stops to two in each direction between Shawmut Avenue and Tremont Street to reduce the number of times buses must stop, to reduce the conflicting demand for curbside space between buses and cars, and to better meet the demand for parking along New Dudley Street. Installing bus shelters would improve conditions for waiting passengers and help to orient them to the new bus stop locations.
- Mark bus loading zones on the pavement with painted bus bays for the full length of the bus reservation.

Tremont Street and Huntington Avenue

Bus Route 66 travels on a segment of Tremont Street running from New Dudley Street to Huntington Avenue. On Huntington Avenue, the bus route runs between Tremont Street and the Jamaica Way underpass. Tremont Street and Huntington Avenue pass through a densely populated area, bordering the Mission Hill neighborhood. Tremont Street is single-lane in each direction, is frequently interrupted by curb cuts, and has frequent signage for tow zones and bus stops.

Car drivers do not heed the signs and frequently park illegally in the bus stops and tow zones. Parking spaces are undefined and unmetered on Tremont Street and cars are generally parked bumper to bumper from the intersection of Tremont Street at Parker Street up to Huntington Avenue.

Huntington Avenue has two lanes of traffic in each direction and a branch of the Green Line running in the center of the street in mixed traffic. Parking appears to be unrestricted on both sides of the street from Tremont Street to South Huntington Avenue with the exception of the bus stops, the trolley stops, and some metered spaces between Tremont Street and Fenwood Street. Spaces are defined by painted lines, yet drivers often try to squeeze two cars into one parking space. Eastbound traffic approaching the Tremont Street intersection experiences significant delays throughout the afternoon. This is likely the result of illegal parking maneuvers on Tremont Street east of the Huntington Avenue intersection.

Due to extensive on-street parking, Tremont Street appears congested and cluttered to drivers. At the Roxbury Crossing T station and bus stop on Tremont Street, parking is restricted to one half hour on both sides of the street. North of there up to Worthington Street, two-hour parking is permitted on both sides of the street. Between Worthington Street and Wigglesworth Street, parking on Tremont Street is "Resident Permit Parking Only". Roxbury Crossing T Station, at the intersection of New Dudley Street, Tremont Street and Columbus Avenue is within walking distance of Brigham Circle at Huntington Avenue. Between these two locations, there are five bus stops in each direction on Tremont Street, spaced at an average interval of 600 feet. They are often blocked by parked cars. Two bus stops on Tremont Street are located quite close to the intersection. When cars park in these bus stops, bus drivers wait in the travel lanes while passengers board and alight. Eastbound, the bus stop between the entrance and exit to the Osco Drug Plaza is clearly marked as a tow zone, but this does not stop drivers from parking. This results in traffic queuing back into the Huntington Avenue intersection. Westbound, the lane blockage causes lost green time in the signal cycle on the Tremont Street approach at Huntington Avenue.

Double-parking is a frequent phenomenon on both Tremont Street and Huntington Avenue. Car drivers tend to double-park in order to run quick errands such as getting a cup of coffee. Despite the extensive commercial activity on Tremont Street near Huntington Avenue, there are no commercial loading zones defined. This leads truck drivers to double-park, blocking a travel lane, often for long periods of time.

Suggested Improvement Strategies:

- Stripe the parking lanes with parking spaces and install meters, to discourage drivers from attempting to fit too many cars in a given segment. There has to be a limit to the number of cars permitted to park on the street; otherwise the congested parking conditions contribute to traffic congestion.
- Forbid on-street parking at locations where the lane geometry is too narrow to accommodate it, such as the curbside fronting the Calumet Market.

- Rather than booting cars for which owners have not paid parking fines, impound them. Tremont Street is too congested an area to lose spaces to booted vehicles.
- Reduce the number of bus stops on both sides of Tremont Street between Roxbury Crossing and Huntington Avenue from five to three in each direction. Once again, reducing the number of stops would free up curb space for on-street parking and reduce the conflict between bus and traffic maneuvers. It would also reduce the geographic area needing enforcement of parking regulations. Mark the pavement at bus stops with large lettering and bus-length bays to clearly distinguish the bus stops from parking spaces.
- Relocate the remaining stops and provide bus shelters to facilitate the change and improve patron comfort.
- Reserve a portion of the curbing on both sides of Tremont Street for commercial loading zones. These should be staggered and not directly across from one another. Time limits on commercial stopping will be necessary to keep people with commercial license plates from using the loading zones as all-day parking spots.
- Look for an appropriate location to site an off-street parking facility.

BROOKLINE

On-street parking is less of an issue for the buses as they travel Harvard Street in Brookline than it is in Roxbury. Most of the parking on Harvard Street is metered, and spaces are painted on the parking lane. No-Parking zones and bus stops are clearly marked. For the most part, drivers obey the parking restrictions in no-parking zones and bus stops. One reason why parking is less of an issue, is that there are several off-street parking lots nearby to accommodate parking demand. Where parking is an issue is at the intersection of Harvard Street with Longwood Avenue, an unsignalized intersection.

Harvard Street at Longwood Avenue and at Beacon Street (Coolidge Corner)

An important source of delay occurs at the intersection of Harvard Street with Longwood Avenue. Left turns from Harvard Street southbound to Longwood Avenue have minimal opportunities for gaps in the northbound traffic. South of Beacon Street at Longwood Avenue, on the southbound side of Harvard Street, there is a clearly marked "No Parking" tow zone. Illegal parking in the tow zone and parked cars at one or two adjacent legal spaces block the southbound through lane while left-turning vehicles queue. The through vehicles then get trapped behind vehicles turning left onto Longwood. Failures on the southbound approach to this intersection cause queues that spill back into Harvard Street at Beacon Street.

Suggested Improvement Strategies:

- Remove two spaces of legal parking on the southbound side of Harvard Street.

- Restripe Harvard Street to narrow the northbound travel lanes approaching Beacon Street and to widen the southbound right lane leaving Beacon Street and approaching Longwood Avenue.
- Paint a through arrow in the southbound right lane at the point where the tow zone is located.

BRIGHTON

Harvard Avenue from Commonwealth Avenue to Cambridge Street

At the town line of Brookline and Brighton, Harvard Street becomes Harvard Avenue. Differences in parking policy between the Town of Brookline and the City of Boston are readily apparent. In Brookline, the provision for on-street parking is well designed. In Brighton, the parking design seems relatively undefined. On-street parking with a two-hour limit is permitted on both sides of the street, but spaces are not metered, nor are they painted on the street. Off-street parking is available in one small city parking lot behind the storefronts, adjacent to the Blanchard's property, but the lot is always full. Double-parking both by consumers and by commercial delivery trucks often blocks the travel lanes. Trucks frequently double-park due to a lack of commercial loading zones.

Brighton Avenue also stands in sharp contrast to Harvard Avenue. Recently redesigned, Brighton Avenue includes a raised median, neck-down curbs at pedestrian crossings, and reservations for on-street parking. The parking lanes are separated from the travel lanes by a solid white line. Individual parking spaces are not defined nor are they metered, but the median, neck-downs and solid lines contribute to an overall effect of increased safety for and friendliness to pedestrians as well as clear environmental definition for drivers. Harvard Avenue would benefit from a similar redesign.

North of Brighton Avenue, Harvard Avenue drops from two lanes to one narrow lane in each direction and has several commercial properties abutting it. On-street parking is permitted on both sides of the street. Off-street parking is nonexistent and double-parking is a common phenomenon. Traffic volumes on this segment of Harvard Avenue exceed roadway capacity, and the parking issues exacerbate the problem. Although the bus route does not travel over this segment of Harvard Avenue, the congestion here affects the bus when double-parked vehicles cause the intersections at either end to fail, creating gridlock conditions.

Suggested Improvement Strategies:

- Paint parking spaces and install parking meters.
- Identify appropriate locations for commercial loading zones and paint reservations for trucks at the curbsides.
- Identify appropriate locations to site off-street parking facilities to serve the high parking demand on Harvard Avenue.
- Paint bus reservations at the bus stops.

- Enforce parking restrictions.

Union Square

At the intersection of Brighton Avenue, Cambridge Street, and North Beacon Street parked cars create a problem for traffic leaving the intersection on North Beacon Street. Though North Beacon is striped for two departure lanes, the width of the road allows for only two lanes, not an additional parking lane. Cars park at the curb, blocking the right travel lane. Illegal parking at the intersection, and the permitted parking farther on forces two lanes of traffic from both Brighton Avenue westbound and Cambridge Street southbound to squeeze into one lane. A set of potential strategies would include:

Suggested Improvement Strategies:

- Enforce parking restrictions.
- Restripe Brighton Avenue to provide for two left-turn lanes and one through lane, eliminating the shared left-and-through lane. This strategy will be evaluated with the Highway Capacity Alternatives Analysis to assess its impacts on traffic.
- Restripe the lanes on Cambridge Street southbound to provide one left-turn lane and one through/right lane. This strategy will be evaluated with the Highway Capacity Alternatives Analysis to assess its impacts on traffic.
- Look for an appropriate location to site an off-street parking facility.
- Consider eliminating parking spaces on North Beacon Street that are too close to the intersection. This strategy was recommended by CTPS in a recent study of Route 20 through Brighton. [1]

Cambridge Street

On Cambridge Street between Brighton Avenue and Harvard Avenue, numerous curb cuts and a lack of pavement markings leave drivers unclear as to where parking is or is not permitted. On-street parking appears to be unrestricted and drivers squeeze their cars in wherever they can.

Suggested Improvement Strategies:

- Paint curbside parking spaces to delineate them from travel lanes, curb cuts, and bus stops.
- Define the parking limits (location and time periods).
- Meter the parking spaces.
- Paint bus stop bays at the bus stops to delineate them from parking spaces and curb cuts.

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[1] *Route 20 Transportation Planning Study*, CTPS for MassHighway, May 1998.

North Harvard Street at Western Avenue

Approaching the intersection of Western Avenue, North Harvard Street bends to the right and the geometry of the road narrows. Sight distance is limited and curbside parking is prohibited. Yet drivers park there anyway.

North of Western Avenue, drivers park on both sides of North Harvard Street up to its intersection with the Soldiers Field Road Ramps. Parking appears to be unrestricted apart from the bus stops and one "No Parking Zone" located on the approach to the Soldiers Field Road ramps within 50 feet of the intersection. Several closely spaced bus stops are generally blocked by parked cars. Approaching Soldiers Field Road, the No-Parking zone is generally blocked by at least six parked cars. At the intersection of North Harvard Street with the ramps for Soldiers Field Road, high traffic volumes on North Harvard Street are confined to a single lane, due to on-street parking.

Suggested Improvement Strategies:

- Enforce parking restrictions.
- Look for an appropriate place to site an off-street parking facility.

CAMBRIDGE

On John F. Kennedy Boulevard, in Cambridge, parking is not permitted between Memorial Drive and Eliot Street. Between Eliot and Brattle Street, metered parking on both sides of John F. Kennedy is restricted to one hour. Spaces are clearly painted on the road. Enforcement of time limits at parking meters in Cambridge is generally strict. North of Mount Auburn Street, John F. Kennedy is fronted by a variety of commercial and retail properties, and trucks frequently double-park to unload products for the local businesses, causing significant traffic delay.

Suggested Improvement Strategies:

- Identify appropriate locations for commercial loading reservations on J. F. Kennedy Boulevard.
- Enforce parking restrictions to eliminate double parking

CONCLUSIONS/RECOMMENDATIONS

Frequent double parking and bumper-to-bumper cramming of vehicles alongside the curbs indicate a heavy demand for parking in Dudley Square, and on Tremont Street, Huntington Avenue, Harvard Avenue, Cambridge Street, and North Harvard Avenue north of Western Avenue. The existing parking supply does not meet the demand. Improvements are needed in how both the supply and the excess demand are managed. Illegal parking causes congestion and delay throughout the corridor. In conclusion, five categories of recommendations are offered:

1) The bus route needs better enforcement of parking regulations from one end of the route to the other. The bus stops should be kept clear of parked cars for passenger safety. Double-parking needs to be eliminated. Frequent violators should have their cars impounded rather than booted (to remove the obstacle).
2) Commercial vehicles need clearly marked reservations where they can load and unload their products without blocking traffic, for businesses on Tremont Street in Roxbury and on Harvard Avenue in Brighton without blocking traffic.
3) Better definition of parking spaces with pavement striping, parking meters and well-defined parking restrictions, combined with a strong enforcement policy, would help to reduce the traffic problems related to on-street parking, and hopefully eliminate the double-parking problems that cause so much delay for the buses. Placing a limit on the number of cars permitted to park on the street would also contribute to pedestrian and passenger safety.
4) License plate surveys and turnover rate studies would help to assess the volume and nature of the parking demand and to assess whether the cars are owned by local residents or by commuters and patrons of local businesses. It may well be that there is competing demand for parking by residents, commuters, and commercial patrons.
5) A study to assess the feasibility of creating off-street parking facilities is recommended, as well.

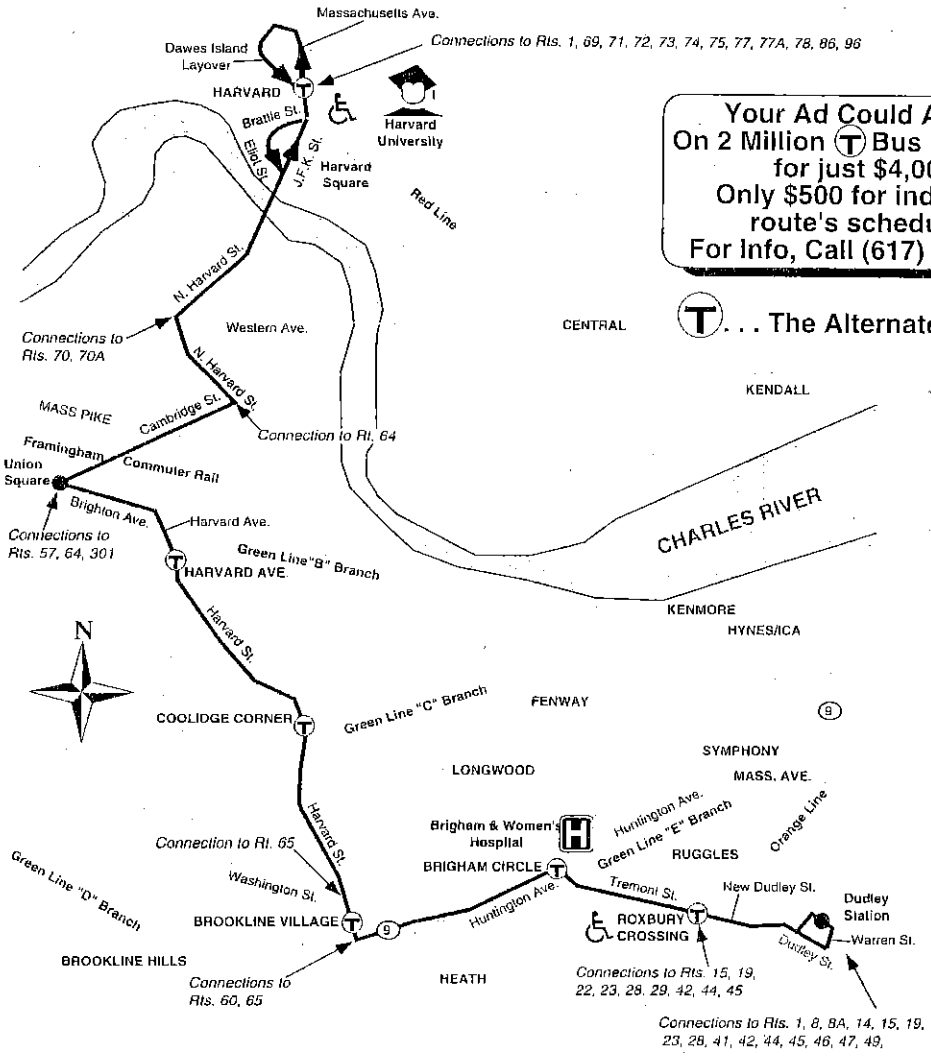
Once it is known what populations are in need of parking in these areas, facilities can be tailored to meet those needs. What distinguishes successful areas from unsuccessful ones is the availability of off-street parking. By relieving demand for parking with off-street facilities, curbside space can be used to provide commercial loading zones, which are desperately needed in several areas on Bus Route 66. While identifying locations where off-street parking facilities could be built may be a long-range, expensive task, the gain for area residents, bus patrons, and bus operations would be worth the expense. Metering the existing parking spaces could provide a revenue stream for a land bank to acquire property or for construction costs of off-street parking facilities.

Appendix G:

Bus Route 66 Schedules

Route 66

Harvard Square - Dudley Station *Via Allston & Brookline Village*



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WINTER Effective December 28, 1996

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Arrive times are approximate, subject to traffic
Please exit rear door

Massachusetts Bay Transportation Authority
William F. Weld, Governor
Paul Cellucci, Lt. Governor
James J. Kerasiotes, Secretary of Transportation
Patrick J. Moynihan, General Manager

66 WEEKDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Arrive Brookline Village	Arrive Dudley Station	Leave Dudley Station	Arrive Brookline Village	Arrive Harvard Square
5:02A	5:20A	5:30A	4:45A	4:53A	5:11A
5:30	5:48	5:58	5:15	5:23	5:41
5:45	6:03	6:13	5:30	5:38	5:56
6:00	6:18	6:28	5:45	5:53	6:11
6:15	6:33	6:43	6:00	6:08	6:26
6:30	6:48	6:58	6:10	6:18	6:36
6:40	6:58	7:11	6:20	6:28	6:46
★	★	★	★	★	★
9:20	9:46	9:59	8:50	9:01	9:25
9:30	9:56	10:09	9:00	9:12	9:36
9:40	10:06	10:19	9:15	9:27	9:51
9:50	10:16	10:29	9:30	9:42	10:06
10:00	10:26	10:39	9:45	9:57	10:21
10:15	10:41	10:54	10:00	10:12	10:36
10:30	10:56	11:09	10:15	10:27	10:51
10:45	11:11	11:24	10:30	10:42	11:06
11:00	11:26	11:39	10:45	10:57	11:21
11:15	11:41	11:54	11:00	11:12	11:36
11:30	11:56	12:09P	11:15	11:27	11:51
11:45	12:11P	12:24	11:30	11:42	12:06P
			11:45	11:57	12:21
12:00N	12:26P	12:39P	12:00N	12:12P	12:36P
12:15P	12:41	12:54	12:15P	12:27	12:51
12:30	12:56	1:09	12:30	12:42	1:06
12:45	1:11	1:24	12:45	12:57	1:21
1:00	1:26	1:39	1:00	1:12	1:36
1:15	1:41	1:54	1:10	1:22	1:46
1:30	1:56	2:11	★	★	★
1:40	2:02	2:21	6:50	7:02	7:25
★	★	★	7:05	7:17	7:40
7:20	7:44	7:56	7:20	7:32	7:55
7:35	7:59	8:11	7:35	7:47	8:10
7:50	8:14	8:26	7:50	8:02	8:25
8:05	8:29	8:41	8:10	8:22	8:45
8:20	8:44	8:56	8:30	8:42	9:04
8:35	8:59	9:09	8:50	9:01	9:19
9:00	9:18	9:28	9:15	9:23	9:41
9:25	9:43	9:53	9:40	9:48	10:06
9:50	10:08	10:18	10:05	10:13	10:31
10:15	10:33	10:43	10:30	10:38	10:56
10:40	10:58	11:08	10:55	11:03	11:21
11:05	11:23	11:33	11:20	11:28	11:46
11:30	11:48	11:58	11:45	11:53	12:11A
11:55	12:13A	12:23A	12:10A	12:18A	12:36
12:25A	12:43	12:53	12:35	12:43	1:01
1:00	1:18	1:28	1:00	1:08	1:26

★ EVERY 10 MINUTES OR LESS

66 SATURDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Arrive Brookline Village	Arrive Dudley Station	Leave Dudley Station	Arrive Brookline Village	Arrive Harvard Square
4:42A	4:59A	5:09A	4:42A	4:50A	5:07A
5:12	5:29	5:39	5:12	5:20	5:37
5:42	5:59	6:09	5:42	5:50	6:07
6:00	6:17	6:27	6:12	6:20	6:37
Ev. 15 Min.	Ev. 15 Min.	Ev. 15 Min.	6:30	6:38	6:55
Until	Until	Until	Ev. 15 Min.	Ev. 15 Min.	Ev. 15 Min.
11:45	12:10P	12:22P	Until	Until	Until
			11:45	11:57	12:21P
12:00N	12:25P	12:37P	12:00N	12:12P	12:36P
Ev. 15 Min.	Ev. 15 Min.	Ev. 15 Min.	Ev. 15 Min.	Ev. 15 Min.	Ev. 15 Min.
Until	Until	Until	Until	Until	Until
7:00P	7:24	7:35	7:15P	7:25	7:46
7:25	7:49	8:00	7:40	7:50	8:11
7:50	8:14	8:25	8:05	8:15	8:36
8:15	8:39	8:50	8:30	8:40	9:01
8:40	9:02	9:12	8:55	9:04	9:21
9:05	9:22	9:32	9:20	9:26	9:45
9:30	9:47	9:57	9:45	9:53	10:10
9:55	10:12	10:22	10:10	10:18	10:35
10:20	10:37	10:47	10:35	10:43	11:00
10:45	11:02	11:12	11:00	11:08	11:25
11:10	11:27	11:37	11:25	11:33	11:50
11:35	11:52	12:02A	11:50	11:58	12:15A
12:00M	12:17A	12:27	12:15A	12:23A	12:40
12:30A	12:47	12:57	12:40	12:48	1:05
			1:00	1:08	1:25

ALL BUSES ON THIS ROUTE ARE EQUIPPED WITH WHEELCHAIR LIFTS

66 SUNDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Arrive Brookline Village	Arrive Dudley Station	Leave Dudley Station	Arrive Brookline Village	Arrive Harvard Square
6:40A	6:57A	7:07A	6:00A	6:08A	6:25A
7:20	7:37	7:47	6:40	6:48	7:05
8:00	8:17	8:27	7:20	7:28	7:45
8:40	8:57	9:07	8:00	8:08	8:25
9:20	9:39	9:52	8:40	8:48	9:05
10:00	10:22	10:35	9:20	9:26	9:50
10:40	11:02	11:15	10:00	10:10	10:32
11:20	11:42	11:55	10:40	10:50	11:12
			11:20	11:30	11:52
			11:50	12:00N	12:22P
12:00N	12:22P	12:35P	12:20P	12:30P	12:52P
12:30P	12:52	1:05	12:50	1:00	1:22
1:00	1:22	1:35	1:20	1:30	1:52
1:30	1:57	2:07	1:50	2:01	2:23
2:00	2:23	2:37	2:20	2:31	2:53
2:30	2:53	3:07	2:50	3:01	3:23
3:00	3:23	3:37	3:20	3:31	3:53
3:30	3:53	4:07	4:00	4:11	4:33
4:00	4:23	4:37	4:40	4:51	5:13
4:40	5:03	5:17	5:20	5:31	5:53
5:20	5:43	5:57	6:00	6:11	6:32
6:00	6:23	6:34	6:40	6:51	7:12
6:40	7:03	7:14	7:20	7:31	7:52
7:20	7:43	7:54	8:00	8:11	8:32
8:00	8:23	8:34	8:40	8:51	9:10
8:40	9:02	9:12	9:20	9:28	9:45
9:20	9:37	9:47	10:00	10:08	10:25
10:00	10:17	10:27	10:35	10:43	11:00
10:35	10:52	11:02	11:10	11:18	11:35
11:10	11:27	11:37	11:45	11:53	12:10A
11:45	12:02A	12:12A	12:20A	12:28A	12:45
12:20A	12:37	12:47	1:00	1:09	1:25

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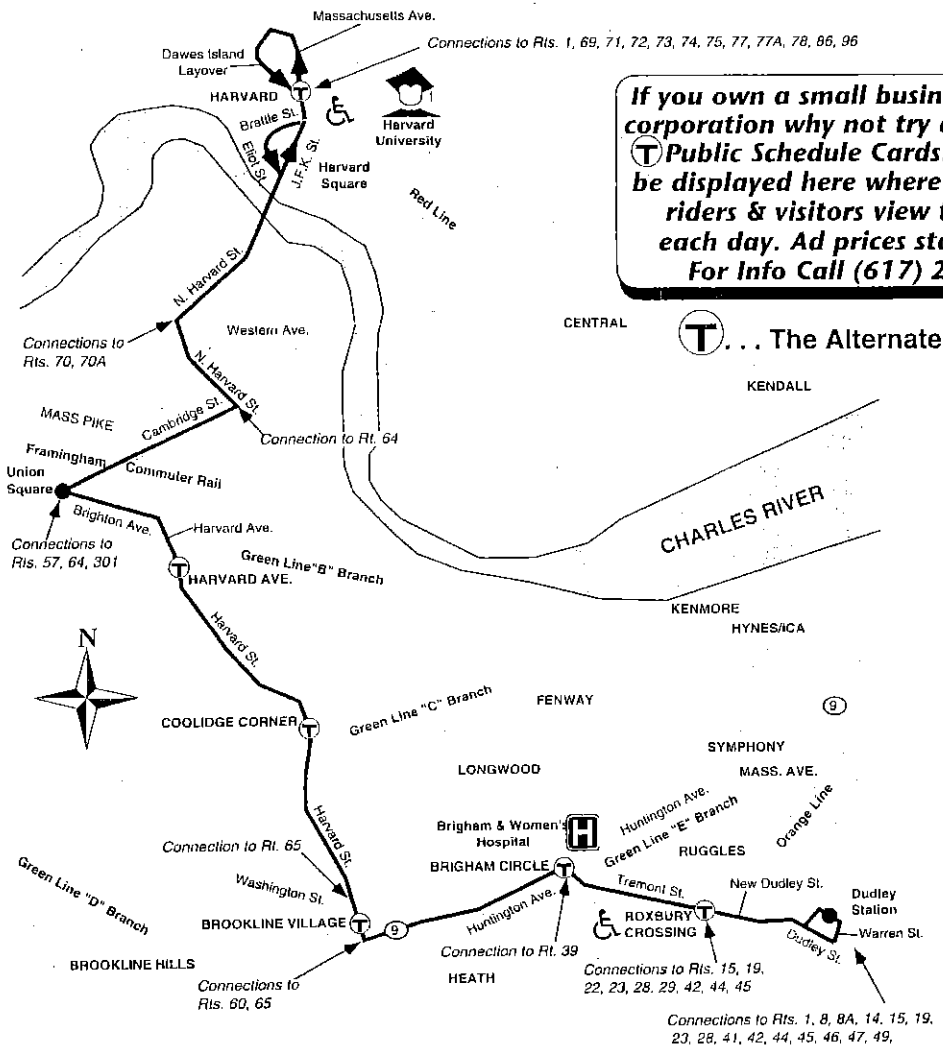
HOLIDAYS:

Jan. 1 - See SUNDAY
Jan. 20 - See SATURDAY
Feb. 17 - See SATURDAY
April 21 - See SATURDAY
May 26 - See SUNDAY

Route 66
Harvard Square - Dudley Station
Via Allston & Brookline Village

Route 66

Harvard Square - Dudley Station Via Allston & Brookline Village



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Massachusetts Bay Transportation Authority
Paul Cellucci, Governor
Patrick J. Moynihan, Secretary and MBTA Chairman
Robert H. Prince Jr., General Manager

66 WEEKDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Arrive Brookline Village	Arrive Dudley Station	Leave Dudley Station	Arrive Brookline Village	Arrive Harvard Square
5:02A	5:20A	5:30A	4:45A	4:53A	5:11A
5:30	5:48	5:58	5:15	5:23	5:41
5:45	6:03	6:13	5:30	5:38	5:56
6:00	6:18	6:28	5:45	5:53	6:11
6:15	6:33	6:43	6:00	6:08	6:26
6:30	6:48	6:58	6:10	6:18	6:36
★	★	★	6:20	6:28	6:46
9:10	9:36	9:49	★	★	★
9:20	9:46	9:59	9:00	9:12	9:36
9:30	9:56	10:09	9:15	9:27	9:51
9:40	10:06	10:19	9:30	9:42	10:06
9:50	10:16	10:29	9:45	9:57	10:21
10:00	10:26	10:39	10:00	10:12	10:36
10:15	10:41	10:54	10:15	10:27	10:51
10:30	10:56	11:09	10:30	10:42	11:06
10:45	11:11	11:24	10:45	10:57	11:21
11:00	11:26	11:39	11:00	11:12	11:36
11:15	11:41	11:54	11:15	11:27	11:51
11:30	11:56	12:09P	11:30	11:42	12:06P
11:45	12:11P	12:24	11:45	11:57	12:21
12:00N	12:26P	12:39P	12:00N	12:12P	12:36P
12:15	12:41	12:54	12:15	12:27	12:51
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2:00	2:26	2:41	1:50	2:03	2:29
2:10	2:36	2:51	s 1:55	2:10	2:36
2:20	2:46	3:01	1:59	2:15	2:41
2:30	2:56	3:11	★	★	★
2:40	3:06	3:21	6:50	7:02	7:25
★	★	★	7:05	7:17	7:40
7:20	7:44	7:56	7:20	7:32	7:55
7:35	7:59	8:11	7:35	7:47	8:10
7:50	8:14	8:26	7:50	8:02	8:25
8:05	8:29	8:41	8:10	8:22	8:45
8:20	8:44	8:56	8:30	8:42	9:04
8:35	8:59	9:09	8:50	9:01	9:19
9:00	9:18	9:28	9:15	9:23	9:41
9:25	9:43	9:53	9:40	9:48	10:06
9:50	10:08	10:18	10:05	10:13	10:31
10:15	10:33	10:43	10:30	10:38	10:56
10:40	10:58	11:08	10:55	11:03	11:21
11:05	11:23	11:33	11:20	11:28	11:46
11:30	11:48	11:58	11:45	11:53	12:11A
11:55	12:13A	12:23A	12:10A	12:18A	12:36
12:25A	12:43	12:53	12:35	12:43	1:01
1:00	1:18	1:28	1:00	1:08	1:26

s - Runs only when school is in session.

★ EVERY 10 MINUTES OR LESS

66 SATURDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Arrive Brookline Village	Arrive Dudley Station	Leave Dudley Station	Arrive Brookline Village	Arrive Harvard Square
4:42A	4:59A	5:09A	4:42A	4:50A	5:07A
5:12	5:29	5:39	5:12	5:20	5:37
5:42	5:59	6:09	5:42	5:50	6:07
6:00	6:17	6:27	6:12	6:20	6:37
6:15	6:32	6:42	6:30	6:38	6:55
6:30	6:47	6:57	6:45	6:53	7:13
6:45	7:03	7:14	7:00	7:11	7:32
7:00	7:23	7:34	7:15	7:26	7:47
7:15	7:38	7:49	7:30	7:41	8:02
7:30	7:53	8:04	7:45	7:56	8:17
7:45	8:08	8:19	8:00	8:11	8:32
8:00	8:23	8:34	8:15	8:26	8:47
Ev. 15 Min. Until	Ev. 15 Min. Until	Ev. 15 Min. Until	8:30 Ev. 15 Min. Until	8:41 Ev. 15 Min. Until	9:02 Ev. 15 Min. Until
11:15	11:40	11:52	11:30	11:42	12:06P
11:30	11:55	12:07P	11:45	11:57	12:21
11:45	12:10P	12:22			
12:00N	12:25P	12:37P	12:00N	12:12P	12:36P
Ev. 15 Min. Until	Ev. 15 Min. Until	Ev. 15 Min. Until	Ev. 15 Min. Until	Ev. 15 Min. Until	Ev. 15 Min. Until
6:00	6:24	6:35	6:15	6:25	6:46
6:15	6:39	6:50	6:30	6:40	7:01
6:30	6:54	7:05	6:45	6:55	7:16
6:45	7:09	7:20	7:00	7:10	7:31
7:00	7:24	7:35	7:15	7:25	7:46
7:25	7:49	8:00	7:40	7:50	8:11
7:50	8:14	8:25	8:05	8:15	8:36
8:15	8:39	8:50	8:30	8:40	9:01
8:40	9:02	9:12	8:55	9:04	9:21
9:05	9:22	9:32	9:20	9:20	9:45
9:30	9:47	9:57	9:45	9:53	10:10
9:55	10:12	10:22	10:10	10:18	10:35
10:20	10:37	10:47	10:35	10:43	11:00
10:45	11:02	11:12	11:00	11:08	11:25
11:10	11:27	11:37	11:25	11:33	11:50
11:35	11:52	12:02A	11:50	11:58	12:15A
12:00M	12:17A	12:27	12:15A	12:23A	12:40
12:30A	12:47	12:57	12:40	12:48	1:05
12:55	1:12	1:22	1:00	1:08	1:25

ALL BUSES ON THIS ROUTE ARE EQUIPPED WITH WHEELCHAIR LIFTS

Route 66
Harvard Square - Dudley Station
Via Allston & Brookline Village

66 SUNDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Arrive Brookline Village	Arrive Dudley Station	Leave Dudley Station	Arrive Brookline Village	Arrive Harvard Square
6:40A	6:57A	7:07A	6:00A	6:08A	6:25A
7:20	7:37	7:47	6:40	6:48	7:05
8:00	8:17	8:27	7:20	7:28	7:45
8:40	8:57	9:07	8:00	8:08	8:25
9:20	9:39	9:52	8:40	8:48	9:05
10:00	10:22	10:35	9:20	9:28	9:50
10:40	11:02	11:15	10:00	10:10	10:32
11:20	11:42	11:55	10:40	10:50	11:12
			11:20	11:30	11:52
			11:50	12:00N	12:22P
12:00N	12:22P	12:35P	12:20P	12:30P	12:52P
12:30P	12:52	1:05	12:50	1:00	1:22
1:00	1:22	1:35	1:20	1:30	1:52
1:30	1:53	2:07	1:50	2:01	2:23
2:00	2:23	2:37	2:20	2:31	2:53
2:30	2:53	3:07	2:50	3:01	3:23
3:00	3:23	3:37	3:20	3:31	3:53
3:30	3:53	4:07	4:00	4:11	4:33
4:00	4:23	4:37	4:40	4:51	5:13
4:40	5:03	5:17	5:20	5:31	5:53
5:20	5:43	5:57	6:00	6:11	6:32
6:00	6:23	6:34	6:40	6:51	7:12
6:40	7:03	7:14	7:20	7:31	7:52
7:20	7:43	7:54	8:00	8:11	8:32
8:00	8:23	8:34	8:40	8:51	9:10
8:40	9:02	9:12	9:20	9:28	9:45
9:20	9:37	9:47	10:00	10:08	10:25
10:00	10:17	10:27	10:35	10:43	11:00
10:35	10:52	11:02	11:10	11:18	11:35
11:10	11:27	11:37	11:50	11:58	12:15A
11:50	12:07A	12:17A	12:30A	12:38A	12:55
12:30A	12:47	12:57	1:00	1:08	1:25
12:55	1:12	1:22			

FARE 60¢

Seniors 65+ w/MBTA Senior ID Card	15¢
Persons w/Disabilities w/Transportation Access Pass (TAP) (Medicare Card holders are automatically eligible for TAP)	15¢
Blind Persons w/Mass. Comm. for Blind ID Card	FREE
Children Ages 11 and under	30¢
Children under 5 yrs.(limit of two, when with adult)	FREE
Students w/MBTA Pupil ID Badge	30¢

EXACT CHANGE REQUIRED

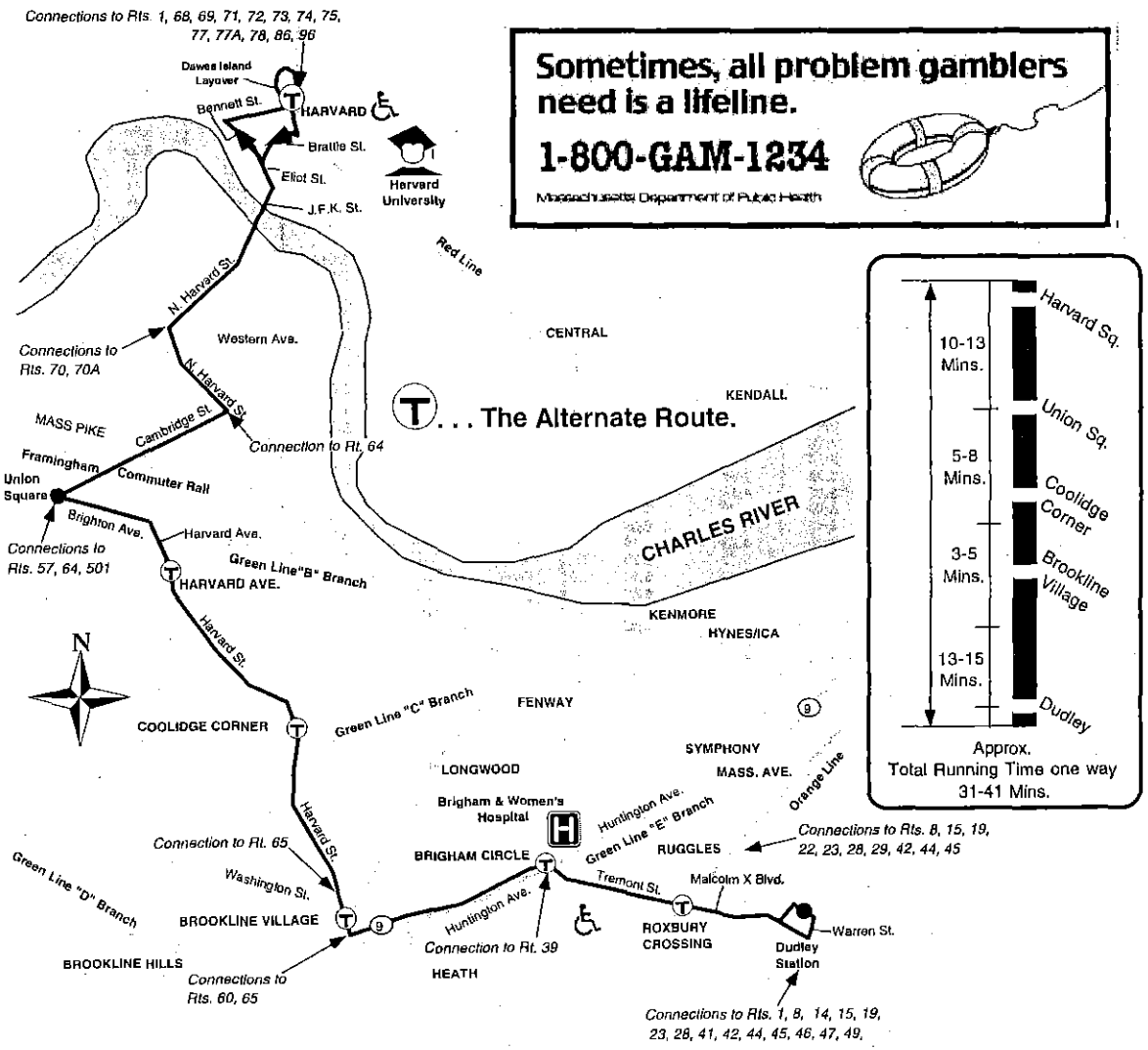
VALID PASSES

Local Bus ($0.60)	$20.00/mo.
Combo ($1.50)	$46.00/mo.
Combo *Plus* ($1.70)	$48.00/mo.
Zone - 1 ($2.00)	$64.00/mo.
Zone - 2 ($2.25)	$72.00/mo.

1998 HOLIDAYS:

Jan. 1 - See Sun.
Jan. 19 - See Sat.
Feb. 16 - See Sat.
April 20 - See Sat.
May 25 - See Sun.
June 17 - See Wkdy
July 4 - See Sun.
Sept. 7 - See Sun.

Route 66 *Harvard Square - Dudley Station Via Allston & Brookline Village*



Sometimes, all problem gamblers need is a lifeline.

1-800-GAM-1234

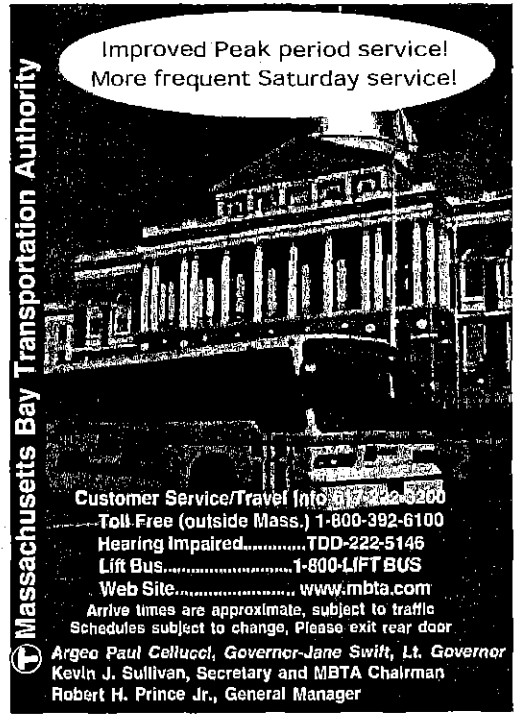
Massachusetts Department of Public Health

schedule change **66**

WINTER Dec. 30, 2000 - March 23, 2001

Harvard Square - Dudley Station Via Harvard St.

Serving: Brigham & Women's Hospital, Brigham Circle, Brookline Village, Coolidge Corner, Union Square, Allston and connections to the Red, Orange & Green Lines


Improved Peak period service!
More frequent Saturday service!
Massachusetts Bay Transportation Authority
Customer Service/Travel Info 617-222-3200
Toll Free (outside Mass.) 1-800-392-6100
Hearing Impaired.....TDD-222-5146
Lift Bus.....1-800-LIFT BUS
Web Site.....www.mbta.com
Arrive times are approximate, subject to traffic
Schedules subject to change, Please exit rear door
Argeo Paul Cellucci, Governor-Jane Swift, Lt. Governor
Kevin J. Sullivan, Secretary and MBTA Chairman
Robert H. Prince Jr., General Manager

66 WEEKDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Leave Union Square	Arrive Dudley Station	Leave Dudley Station	Leave Union Square	Arrive Harvard Square
5:02A	5:12A	5:30A	4:45A	5:01A	5:11A
5:30	5:40	5:58	5:15	5:31	5:41
5:45	5:55	6:13	5:30	5:46	5:56
6:00	6:10	6:28	5:45	6:01	6:11
6:15	6:25	6:43	6:00	6:16	6:26
6:25	6:35	6:53	6:10	6:26	6:36
★	★	★	6:19	6:35	6:45
9:10	9:23	9:49	★	★	★
9:20	9:33	9:59	9:01	9:25	9:37
9:30	9:43	10:09	9:15	9:39	9:51
9:40	9:53	10:19	9:30	9:54	10:06
9:50	10:03	10:29	9:45	10:09	10:21
10:00	10:13	10:39	10:00	10:24	10:36
10:15	10:28	10:54	10:15	10:39	10:51
10:30	10:43	11:09	10:30	10:54	11:06
10:45	10:58	11:24	10:45	11:09	11:21
11:00	11:13	11:39	11:00	11:24	11:36
11:15	11:28	11:54	11:15	11:39	11:51
11:30	11:43	12:09P	11:30	11:54	12:06P
11:45	11:58	12:24	11:45	12:09P	12:21
12:00N	12:13P	12:39P	12:00N	12:24P	12:36P
12:15	12:28	12:54	12:15	12:39	12:51
12:30	12:43	1:09	12:30	12:54	1:06
12:45	12:58	1:24	12:45	1:09	1:21
1:00	1:13	1:39	1:00	1:24	1:36
1:15	1:28	1:54	1:10	1:34	1:46
1:30	1:43	2:11	1:20	1:44	1:56
1:40	1:53	2:21	1:30	1:54	2:06
1:50	2:03	2:31	1:40	2:05	2:17
2:00	2:13	2:41	1:50	2:17	2:29
2:10	2:23	2:51	s 1:55	2:24	2:36
2:20	2:33	3:01	1:59	2:29	2:41
2:30	2:43	3:11	ms 1:50	2:30	-
★	★	★	★	★	★
7:20	7:33	7:56	6:52	7:15	7:27
7:35	7:48	8:11	7:05	7:28	7:40
7:50	8:03	8:26	7:20	7:43	7:55
8:05	8:18	8:41	7:35	7:58	8:10
8:20	8:33	8:56	7:50	8:13	8:25
8:35	8:48	9:09	8:10	8:33	8:45
9:00	9:10	9:28	8:30	8:53	9:04
9:25	9:35	9:53	8:50	9:00	9:19
9:50	10:00	10:18	9:15	9:31	9:41
10:15	10:25	10:43	9:40	9:56	10:06
10:40	10:50	11:08	10:05	10:21	10:31
11:05	11:15	11:33	10:30	10:46	10:56
11:30	11:40	11:58	10:55	11:11	11:21
11:55	12:05A	12:23A	11:20	11:36	11:46
12:25A	12:35	12:53	11:45	12:01A	12:11A
w 1:00	1:10	1:28	12:10A	12:26	12:36
			12:35	12:51	1:01
			w 1:00	1:16	1:26

w - Waits for last train to arrive at Station.
s - Runs ONLY when school is in session.
m - Malcolm X. Blvd. to Union Sq.

★ EVERY 10 MINUTES OR LESS

66 SATURDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Leave Union Square	Arrive Dudley Station	Leave Dudley Station	Leave Union Square	Arrive Harvard Square
4:42A	4:49A	5:05A	4:42A	4:59A	5:09A
5:12	5:19	5:35	5:12	5:29	5:39
5:42	5:49	6:05	5:42	5:59	6:09
6:00	6:07	6:23	6:12	6:29	6:39
6:15	6:22	6:38	6:30	6:47	6:57
6:30	6:37	6:53	6:45	7:02	7:12
6:45	6:52	7:11	7:00	7:17	7:27
Every	15 Mins.	Until	Every	15 Mins.	Until
11:15	11:27	11:54	11:30	12:04P	12:16
11:30	11:42	12:12P	11:45	12:19	12:31
11:45	11:57	12:29			
			12:00N	12:34P	12:46P
12:00N	12:18P	12:50P	12:15P	12:49	1:01
12:15P	12:33	1:05	12:30	1:04	1:16
12:30	12:48	1:20	12:45	1:19	1:31
12:45	1:03	1:35	1:00	1:34	1:46
1:00	1:18	1:50	1:15	1:49	2:01
1:15	1:33	2:05	1:30	2:03	2:15
1:30	1:48	2:20	1:45	2:14	2:26
1:45	2:03	2:35	2:00	2:28	2:40
2:00	2:18	2:50	2:15	2:43	2:55
2:15	2:33	3:05	2:30	2:58	3:10
2:30	2:48	3:20	2:45	3:13	3:25
2:45	3:03	3:35	3:00	3:28	3:40
3:00	3:18	3:50	3:15	3:43	3:55
3:15	3:33	4:05	3:30	3:58	4:10
3:30	3:48	4:20	3:45	4:13	4:25
3:45	4:03	4:35	4:00	4:28	4:40
4:00	4:18	4:50	4:15	4:43	4:55
4:15	4:33	5:04	4:30	4:58	5:10
4:30	4:48	5:17	4:45	5:13	5:25
4:50	5:07	5:36	5:00	5:28	5:41
5:10	5:26	5:55	5:15	5:39	5:52
5:30	5:46	6:14	5:35	5:59	6:12
5:50	6:05	6:30	5:55	6:19	6:32
6:10	6:24	6:49	6:15	6:39	6:52
6:30	6:44	7:09	6:35	6:59	7:12
6:50	7:04	7:29	6:55	7:19	7:32
7:10	7:24	7:49	7:15	7:39	7:52
7:30	7:44	8:09	7:40	8:03	8:14
7:50	8:04	8:29	8:05	8:25	8:36
8:15	8:29	8:50	8:30	8:50	9:01
8:40	8:51	9:12	8:55	9:15	9:26
9:05	9:16	9:37	9:20	9:40	9:51
9:30	9:41	10:02	9:45	10:05	10:16
9:55	10:06	10:27	10:10	10:30	10:40
10:20	10:31	10:52	10:35	10:49	10:59
10:45	10:56	11:17	11:00	11:14	11:24
11:10	11:21	11:42	11:25	11:39	12:49A
11:35	11:46	12:07A	11:50	12:04A	12:14
12:00M	12:11A	12:32	12:15A	12:29	12:39
12:25A	12:36	12:57	12:40	12:54	1:04
w 12:55	1:06	1:27	w 1:00	1:14	1:24

Route 66
Harvard Square - Dudley Station
Via Allston & Brookline Village

ALL BUSES ON THIS ROUTE ARE EQUIPPED WITH WHEELCHAIR LIFTS

66 SUNDAY

INBOUND			OUTBOUND		
Leave Harvard Square	Leave Union Square	Arrive Dudley Station	Leave Dudley Station	Leave Union Square	Arrive Harvard Square
6:40A	6:49A	7:07A	6:00A	6:16A	6:25A
7:20	7:29	7:47	6:40	6:56	7:05
8:00	8:09	8:27	7:20	7:36	7:45
8:40	8:49	9:07	8:00	8:16	8:25
9:20	9:29	9:52	8:40	8:56	9:05
10:00	10:12	10:35	9:20	9:39	9:50
10:40	10:52	11:15	10:00	10:21	10:32
11:20	11:32	11:55	10:40	11:01	11:12
			11:20	11:41	11:52
			11:50	12:11P	12:22P
12:00N	12:12P	12:35P	12:20P	12:41P	12:52P
12:30P	12:42	1:05	12:50	1:11	1:22
1:00	1:12	1:35	1:20	1:41	1:52
1:30	1:42	2:07	1:50	2:12	2:23
2:00	2:12	2:37	2:20	2:42	2:53
2:30	2:42	3:07	2:50	3:12	3:23
3:00	3:12	3:37	3:20	3:42	3:53
3:30	3:42	4:07	4:00	4:22	4:33
4:00	4:12	4:37	4:40	5:02	5:13
4:40	4:52	5:17	5:20	5:42	5:53
5:20	5:32	5:57	6:00	6:21	6:32
6:00	6:12	6:34	6:40	7:01	7:12
6:40	6:52	7:14	7:20	7:41	7:52
7:20	7:32	7:54	8:00	8:21	8:32
8:00	8:12	8:34	8:40	9:01	9:10
8:40	8:52	9:12	9:20	9:36	9:45
9:20	9:29	9:47	10:00	10:16	10:25
10:00	10:09	10:27	10:35	10:51	11:00
10:35	10:44	11:02	11:10	11:26	11:36
11:10	11:19	11:37	11:50	12:06A	12:15A
11:50	11:59	12:17A	12:30A	12:46	12:55
12:30A	12:39A	12:57	w 1:00	1:16	1:25
w 12:55	1:04	1:22			

FARE 75¢

Seniors 65+ w/MBTA Senior ID Card	15¢
Persons w/Disabilities w/Transportation Access Pass (TAP) (Medicare Card holders are automatically eligible for TAP)	15¢
Blind Persons w/Mass. Comm. for Blind ID Card	FREE
Children Ages 11 and under	35¢
Children under 5 yrs. (limit of two, when with adult)	FREE
Students w/MBTA Pupil ID Badge	35¢

EXACT CHANGE REQUIRED

VALID PASSES

Local Bus ($0.75)	$25.00/mo.
Combo ($1.75)	$57.00/mo.
Combo *Plus* ($2.00)	$63.00/mo.
Zone - 1 ($2.50)	$85.00/mo.
Zone - 2 ($2.75)	$94.00/mo.

2001 HOLIDAYS:

Jan. 1 - See Sun.
Jan. 15 - See Sat.
Feb. 19 - See Sat.
April 16 - See Sat.
May 28 - See Sun.
June 17 - See Sun.

Appendix H:

Overview of Adaptive Traffic Signal Control for Transit

The following transcript on adaptive traffic signal control (and its direct application to transit) is an excerpt taken from:

> *Advanced Public Transportation Systems: The State of the Art—Update 1998*, various authors (including staff from Volpe National Transportation Systems Center and Multisystems, Inc.) for U.S. Department of Transportation, Federal Transit Administration, Office of Mobility Innovation, Washington, D.C.; document number FTA-MA-26-7007-98-1; January 1998.

2.6 TRAFFIC SIGNAL PRIORITY TREATMENT

Traffic signal priority treatment, formerly referred to as "signal pre-emption," is a technology by which a traffic signal may be held green (or made green earlier than scheduled) so that a particular vehicle may pass through the intersection more quickly. This technology has been in place for a number of years for emergency vehicles, such as police, fire, and ambulance, since there are times when it is very important for these vehicles to arrive at their destination as soon as possible.

In the case of transit, there are similar, yet different reasons for giving a vehicle priority. Although many hold to the strategy of maximizing the number of vehicles passing through an intersection each cycle, an alternative strategy is to maximize the number of *people* passing through an intersection each cycle. Since transit vehicles (especially buses) generally carry more people than the average automobile, it is consistent with this alternative strategy to shorten their delay as much as possible.

Another benefit arises in very large cities and when headways are short. A common problem under these conditions is "bunching," a situation in which one or more vehicles closely follow another. Thus, if the headway were five minutes, one might see two buses in close proximity, and then not see another for close to ten minutes. Although there are many causes for this occurrence, one remedy is to give priority to buses that are running late, but not those that are running ahead of schedule or closely following another bus. In this way, the spacing between the two is increased.

There are many issues to address, however, if priority treatment is not to upset other traffic control measures in place. For example, traffic signals on many major streets are timed so that vehicles traveling at the speed limit will be held by as few red lights as possible. Advancing or extending the green signal phase for an approaching bus may upset this timing if appropriate strategies are not implemented. The effect on traffic on cross streets also must be considered, especially if these cross streets are major streets. These issues make traffic signal priority treatment for transit vehicles an issue of debate, both among transportation professionals and the automobile-driving public. If not carefully done, granting buses preferential treatment may degrade traffic flow for automobiles and adversely affect bus movements as well. This would be particularly harmful if traffic volumes are approaching saturation levels. The placement of bus stops is also an issue. Bus stops should not be located so that a bus would be at a stop picking up passengers (before reaching an intersection) after having triggered the preferential treatment at the signal.

State-of-the-Art Summary

Traffic signal priority is an established technology for rail systems. The existence of a fixed guideway (the rails), provides a conduit for sensors and wires which may be connected directly to either railroad crossing gates or traffic signals. Many years ago, railroad operators and transit systems developed and implemented this technology and have made it commonplace.

The absence of a fixed guideway, as in the case of bus operations, made it necessary to develop a different method of implementing traffic signal priority. The first priority systems were for emergency vehicles, whose need for the quickest path to their destination is very clear. In the 1970s, there were a number of tests for priority treatment on transit. These systems were manual; they were either driver-actuated or continuous, always giving priority. In each case, the bus, independent of any central control, was loaded with hardware which sent out a signal — either an infrared beam, similar to a remote control or garage door opener, or low-powered radio signals — to activate the priority.

In the 1990s, although priority for transit is still not widespread, the technology has advanced significantly. Often, modern traffic signal priority systems are implemented as part of AVL systems. This not only saves hardware costs, but allows for selective priority. For example, priority may be

denied to a bus which is running ahead of schedule, so that it does not get further ahead of schedule. Also, it does not leave the decision of priority to the driver, who might want to finish his or her route as quickly as possible.

Application Examples

Minneapolis/St. Paul, Minnesota

The Minnesota DOT traffic management center, which manages traffic on Twin Cities metropolitan freeways and coordinates a variety of programs with Metro Transit (see Section 5.3), also controls bus priority. Minnesota DOT's original bus priority test was the "Speedlight" project that allowed buses to pre-empt ramp meters at one location on I-394. Seen as a precursor to a network of ramp bypass lanes (discussed below) needed to address 10- to 15-minute ramp queues at many locations, Speedlight successfully provided signal pre-emption to buses equipped with electronic tags. The tag notified the signal controller to shorten the ramp signal cycle for the approaching bus and any other vehicles queued ahead of it.

Although Speedlight was a successful test, the Minnesota DOT is implementing a more flexible system, dubbed "Synchrolight." Synchrolight involves shortening the ramp signal cycle on a pre-set basis from the centralized signal control center during the morning and evening rush hours. It is a low cost solution since no new equipment has to be purchased, tested, or installed. The agency is starting with a six- to eight-minute window based on the expected schedules of buses using the ramps at approximately 13 locations. A bus should receive priority even if it is running behind schedule since Synchrolight will probably have reduced the queue in advance of its arrival at the ramp. Again, this system is seen as an interim measure as the agency constructs ramp bypass lanes for both buses and emergency vehicles.[72]

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[72] Glen Carlson, Minnesota Department of Transportation Traffic Management Center, Minneapolis, Minnesota.

Montgomery County, Maryland

Traffic signal priority treatment for Ride-On buses is a key transit component of the Montgomery County Transportation Management Center (TMC; see Section 5.3). (The Ride-On transit system includes 3,000 miles of roadways and 200 miles of critical traffic links.) Unlike some signal priority schemes that involve direct communications between a bus' mobile data terminal and the traffic controller, the Montgomery County TMC receives location and on-time status information from vehicles, processes it, and sends directions to the signal controller that: 1) priority is not necessary because the signal is already in or about to change to a green phase; 2) grant priority by extending the green phase, or; 3) deny priority based on a combination of signal phasing, vehicle schedule adherence, impact on traffic in the vicinity, or known special events. The TMC has the capability to deny all priority requests based on traffic incidents such as special events, weather conditions, etc.

When implemented, the County is considering integrating automatic passenger counting data into the signal priority algorithm so that an extended green cycle would only be granted if the transit vehicle was carrying a minimum load.[73]

Seattle, Washington

The Washington State DOT uses King County Metro's AVL data to implement traffic signal priority treatment. In addition to using bus location information to help determine when to grant priority, the agency uses the buses as probes to determine the effect of priority on traffic flow. Because the signal priority arrangement is so new, the agency is planning to hire a staff person to coordinate with local transit service providers to develop protocols, procedures, and standards for signal priority. A primary concern of the Washington State DOT is the impact signal priority might have on the regular traffic flow.[74]

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[73] Alfie Steele and Bill Corder, Montgomery County Transportation Management Section, Rockville, Maryland.

[74] Dave Berg, Washington Department of Transportation Northwest Region, Seattle, Washington.

Chicago, Illinois

As part of its new AVL installation (see Section 2.3), the Chicago Transit Authority is implementing traffic signal priority treatment for its buses at five downtown intersections. Like other large areas, downtown Chicago is a challenging environment for peak-hour bus operations. During rush hour, bus headways on some routes can be as short as 90 seconds. This, combined with high passenger loads and heavy vehicle traffic on the street, slows buses and can very easily lead to bunching. It is hoped that, by giving buses selective priority at these traffic signals (using the AVL system data to determine whether it is needed), even headways may be maintained.[75]

[75] David Phillips and Ronald Baker, Chicago Transit Authority, Chicago, Illinois.

Appendix I:

Agency Coordination (Technical Memorandum)

MEMORANDUM

TO: **Mark Berger, Statewide Planner at MassHighway**
David Carney, MBTA Service Planning

July 7, 1999

FROM: **Amanda Amory**

RE: **MBTA Bus Route 66 Arterial Improvement Study: Agency Coordination**

This memo documents the coordination efforts outlined in the work program for studying the potential for improving traffic conditions along the MBTA Bus Route 66. Local engineers and planners for Boston, Brookline, and Cambridge were contacted, as were representatives of the Metropolitan District Commission (MDC). This coordination was intended to let the communities know about the study, collect available information, and solicit ideas for improvements.

The traffic engineers made available copies of the signal permits on file and information on transportation improvement plans relevant to the study area. Signal permits provided input data for the Highway Capacity Software level-of-service analysis. The summary of improvement projects provides a background on potential changes to the existing traffic controls and anticipated changes in future traffic levels. That summary is presented in an appendix to this memo. Upon completion of the analysis of existing conditions, we presented preliminary findings to the town engineers, and asked them for their improvement suggestions and strategies, which are included in the following documentation of the coordination efforts.

CTPS held meetings with the traffic engineers of Boston, Brookline, Cambridge, and the MDC to obtain their perspectives on the traffic problems identified in the recent travel time study, the field reconnaissance, and the existing conditions analysis. In attendance at these meetings were Mark Berger of the Bureau of Transportation Planning and Development at MassHighway, and David Carney, Manager of Service Planning at the MBTA. A summary of these meetings and additional conversations presented below. As proposed improvements are developed in their communities, all these representatives will be consulted for their comments.

Boston Transportation Department

Para M. Jayasinghe, P.E., Director	(617) 635-4691
Donald Burgess, ITS Program Manager	(617) 635-4688
Alfredo Villar, Operations and Schedules	(617) 635-4681

The city might be willing to consider signal priority for buses, should there be a funding source identified. We also determined that the existing signal priority system was still working at some locations along the B and E lines in the city of Boston.

There was a discussion of the Commonwealth Avenue Segment B project. Our study's recommendations at the intersection of Harvard Street at Commonwealth Avenue may be contingent upon the status of this project. We still need to get a copy of the design report and see what recommendations are listed there, then find out the time frame for implementation or the reasons for delay.

Boston Redevelopment Authority

Phone conversations were held to obtain data on plans and developments.

Arthur Jemison, Regional Deputy Director	(617) 918 4377
Mohamed Ali-Salaam, Neighborhood Planner for Roxbury	(617) 918-4332
Lance Campbell, Neighborhood Planner for Brighton	(617) 918-4311
Jim McGee, Senior Project Manager	(617) 918-4348

Brookline Engineering/Transportation Division

Jack Harris, Director	(617) 730-2139
Jeffrey Parenti, Traffic Engineer	(617) 730-2139
William Smith, Traffic Engineer	(617) 730-2139

On January 6, 1999, we met with Jack Harris and Jeff Parenti of the Brookline Engineering/Transportation Division. We discussed the findings of the travel time study and the highway capacity analysis, as well as some of the recent construction efforts and plans for the Harvard Street area. The Beacon Street and Harvard Street projects are central to traffic management plans in Brookline. The town anticipates upgrading and coordinating 22 signals on Beacon Street, including priority for Green Line trolleys. Recent installations of signals on Harvard Street north of Beacon Street would be coordinated with the Beacon Street system.

Plans for a new hotel to be built on the town-owned Webster Street parking lot include installation of traffic signals on Harvard Street at Webster Street and at Longwood Avenue. These signals would be included in the Beacon Street signal coordination system.

The town expects some short-term disruptions to traffic flow on Harvard Street in the near future due to an MWRA water valve replacement project. Extent of the work is from Beacon Street to Marion Street. Following that will be a roadway resurfacing project.

Discussed the time frame for the implementation of the Beacon Street project, the MWRA project, and the Webster Street project. Asked the question of whether it made sense to make recommendations for short-term improvements at Harvard and Beacon streets or to wait for implementation of the three projects before making suggestions for improvements.

Discussed the likelihood of the town approving removal of parking spaces or relocation of bus stops for the sake of improving traffic flow at strategic locations. The idea was met with positive interest. Subsequent conversations with Jeff Parenti revealed specific ideas for either removing or relocating the outbound stop on Harvard Street at Beacon.

There are plans to add a pedestrian signal between Brookline Avenue and South Huntington Street. Also discussed the idea of installing pedestrian signals at the pedestrian crossings between Aspinwall and Washington Street on Harvard Street.

Discussed retiming the signal at Washington Street and Harvard Street and plans to coordinate the Aspinwall/School Street system with the Washington Street system.

Discussed signal priority for buses. The town would need to study up on this extensively. In the past, signal priority for trolleys was up for discussion, and the town said no, fearful of the effects on traffic operations if signal control were given to the trolleys. Extension of the green phase is preferred. Perspectives on signal priority are changing. Six intersections are now equipped with Opticom assemblies, and two fire vehicles have emitters. The town is interested in seeing demonstrations of signal priority, and would like to see a proposal for the Opticom system plan. It would be necessary to convince the Town Transportation Board of the viability of this project.

Metropolitan District Commission

Julia O'Brien, Director of Planning	(617) 727-5114
Kenneth Kerwin, Traffic Engineer	(617) 727-5114
Rick Corsi,	(617) 727-9693 ext. 263
Herb Nolan, Goody, Clancy and Associates	(617) 262-2760

On January 8, 1999, we met with Julia O'Brien, Director of Planning, and Mr. Kenneth Kerwin, Traffic Engineer, of the Metropolitan District Commission to discuss the findings of the travel time study and the level-of-service analysis. We discussed several alternatives to test to accommodate left turns at the two MDC intersections:

- Prohibiting left turns off Memorial Drive–each approach, both approaches, peak periods only, or 24 hours. Would need to identify an alternative path for diverted traffic.
- Adding a lag green for JFK southbound–was met with resistance since it defeats MDC objectives for Memorial Drive.
- Adding left-turn indicators and striping the approaches for left turns.
- Changing the cycle lengths and phase plans–Ken Kerwin's view is that changing the cycle lengths without coordination will exacerbate the queues on Lars Anderson Bridge.
- Implementing coordination between the two signals. This would require installing conduit in the Lars Anderson Bridge. The MDC would prefer to keep autonomous control of the two signals but recognizes that coordination with the Cambridge system may be necessary.
- Eliminating parking on Memorial Drive is viewed as political, and very likely, unachievable.
- Signal priority.
- Will need to identify funding sources for upgrading the signals, installing coordination and conduit, and signal priority equipment.

Cambridge Transportation Department

David Bryant, Traffic Engineer	(617) 349-4700

He gave me a description and tour of the traffic control system in place in the city of Cambridge. They use an Eagle system, and all of the Harvard Square signals are connected to the system. He stated that recent traffic and pedestrian volume data was unavailable.

Cambridge Community Development Office

Rosalee Anders, Administrative Assistant, Pedestrian Planner	(617) 349-4604
Joseph Barr, Transportation Demand Management Planner	(617) 349-4604

I spoke with representatives of the Cambridge Community Development Office in an attempt to gain information on the two developments being built in Harvard Square. I had hoped there would be information on pedestrian volumes and traffic mitigation strategies for project impacts. Neither of the projects were required to go through the environmental review process; unfortunately information was not available. They were able to provide some information regarding the Charles River Master Plan and directed me to people who could help me get more information.

Massachusetts Bay Transportation Authority

David Carney, Manager, Service Planning	(617) 222-1626

Discussed the options he and the MBTA are interested in pursuing to improve bus service in the corridor. Included in the options are:

- Retime signals, optimize, and coordinate. The issue is how do we define optimizing? Don't slow the Green Line. Also, since some of the most serious delays occur at the Commonwealth and Beacon Street intersections, should there be an immediate focus on Commonwealth Avenue and Beacon Street, or should we ignore them and wait for implementation of the reconstruction projects?
- Moving and reducing the number of stops–far-side stops may reduce delays.
- Schedule changes–increasing running times during peak of the peaks. A question that needs to be answered, if possible, is when and where do buses begin to fall behind schedule?
- He would be interested in removing some selected parking spaces which make bus operations difficult. We should also discuss with police and city officials what their experience has been with enforcement of double-parking prohibitions.
- The MBTA is also interested in exploring further a signal priority system for buses. Are towns willing to consider Opticom signal priority, or conditional priority? Issues include the extent of disruption of signal timing patterns brought about by a queue jump and who would have control of the priority, the town or the MBTA.

We might want to recommend a pilot project for signal priority. Such a project would require installation of a vehicle location system, emitters on the buses, and programmed Opticom signal equipment. Some of the vendors have expressed interest in such a project. At a transit vendors' show April, 1998, I discussed the possibility of such a study with several of the vendors, including potential costs. The figures they mentioned were widely disparate.

Three types of vehicle location systems are possible:

1. Radio frequency tags and readers.
2. Transmitters on buses read through standard vehicle loop detectors embedded in the pavement. (Costly, requires frequent repair.)
3. GPS transmitters.

Objectives of signal priority:

1. Reduce transit travel times for participating buses.
2. Minimize impact on delay to the cross street traffic
3. Reduce traffic delay for participating buses.
4. Increase bus ridership for participating buses

Finally, David wanted to know, if all improvements are made, what would be the expected running times?

Appendix
Recent Projects and Future Plans

The information on the projects discussed below was obtained from the above contacts. Both transportation improvements and major developments are listed.

MBTA Section 5307 project: Key Stations Green Line: B, C, D, E

The MBTA is currently working on an extensive project that affects four intersections in the study area. The Americans with Disabilities Act of 1990 requires that all transit vehicles used on fixed routes must be accessible to individuals with disabilities. "Key" existing transit stations must also be made accessible. In compliance with ADA, the MBTA submitted a *Key Stations Plan* to the FTA, detailing the improvements necessary to make its "key" stations ADA compliant. The MBTA will operate low floor cars and raise platforms approximately eight inches. Depending upon the station, the project may entail platform relocation or station reconstruction. Four stations from the plan are in the Bus Route 66 study area:

"B" Branch - Harvard Avenue - at Commonwealth Avenue
"C" Branch - Coolidge Corner - at Beacon Street and Harvard Street
"D" Branch - Brookline Village - at Station Street
"E" Branch - Brigham Circle - at Huntington Avenue at Tremont Street

Roxbury

All of these are either future plans or are projects are under consideration.

Huntington Avenue Reconstruction Project – MHD File 601046

Listed in the Transportation Improvement Program. The city of Boston, MassHighway, and the MBTA will reconstruct Huntington Avenue from Fenwood Road to Massachusetts Avenue in an effort to improve safety for pedestrians, access to the Green Line, directional signage, and the overall aesthetics of the corridor. The project consists of roadway and sidewalk reconstruction, a new street lighting system along the sidewalks and within the MBTA reservation, upgrades to the traffic signal system, and installation of trolley-detection equipment for a trolley priority system to be controlled by the BTD traffic control center. Construction of left-turn lanes is proposed where feasible to improve traffic operations. Reconstruction of several MBTA stations (including the station at Brigham Circle) for compliance with the American with Disabilities Act is a significant component of the project. Two intersections on the bus route are affected by the project: Huntington Avenue at Tremont Street and Huntington Avenue at Fenwood Road.

Parcel P3

Boston Redevelopment Authority;
Located near New Dudley Street and Columbus Avenue, the development proposal includes a supermarket and commercial space.

Boston Islamic Center Mosque

New Dudley and Elmwood streets:

Social Security Administration

New Dudley and Shawmut streets: A renovation of the former boys and girls club building into commercial and office space for the Social Security Administration.

Brookline

Harvard Street Improvements Project

The project made pedestrian and vehicular safety improvements to Harvard Street in the form of restriping for clearer channelization and street crossings, and pavement rehabilitation. Three new signals were installed, at Verndale Street, at Fuller Street, and at Stedman and Williams streets. The parking lanes on either side of Harvard Street were widened to 10 feet, and the travel lanes were narrowed to 15 feet in order to discourage drivers from forming two lanes of traffic and passing on the right. Several neck-downs were installed to define the parking lane and improve pedestrian safety at the crosswalks. Improvements were made to the sidewalk and streetscape to enhance the visual environment. In addition, a fiber optic conduit was installed during the summer of 1998. This project was completed in the spring through fall of 1997 and 1998.

TJ Maxx

TJ Maxx recently opened a new store on Harvard Street, across from Verndale Street, just south of the Boston/Brookline town line. To mitigate anticipated traffic problems, the signal at Verndale was upgraded from a pedestrian-actuated signal to a fully actuated signal controlling the driveway at TJ Maxx. The upgrade was part of the Harvard Street Improvements Project.

Stop & Shop Expansion

The project expanded the parking lot of the Stop & Shop property. Access and egress to the lot was moved south on Harvard Street, across from Harris Street. A fully actuated signal was installed which controls the left and right turns into and out of the driveway and provides an actuated pedestrian phase. The signal replaced the older pedestrian signal at Vernon Street, which was removed. The expansion was completed in the summer of 1998.

MWRA Water Main Valve Replacement Project

The project will involve opening up Beacon Street at Coolidge Corner to replace water main valves. Traffic flow will be disrupted during the course of the project–planned mitigation efforts are unclear. Scheduled to commence Spring 1999.

Beacon Street Reconstruction Project

Vanasse Hangen Brustlin, Inc., was commissioned by the town of Brookline to prepare final design plans for roadway infrastructure improvements to Beacon Street in Brookline. The intent of the design is to upgrade to signal controllers and replace the interconnect system with a closed-loop signal system. The project will include pedestrian safety improvements, MBTA trolley enhancements, accommodation of bicycles, and roadway and landscape improvements. At Harvard Street, the signal will be upgraded and the MBTA grade crossing will be rubberized.

The Green Line station platforms at Beacon Street and Harvard Street are listed on the MBTA's *Key Stations Plan.* The Beacon Street Reconstruction Project design objectives reduce traffic conflicts at grade crossings and increase green time for trolleys. At Harvard Street, left turns are not and will not be permitted. The new closed-loop signal coordination system will give unused green time to Beacon Street and the trolleys. The project is currently at the 25% design stage and is programmed in the TIP for construction in the year 2001.

Webster Street Hotel

The town of Brookline is in the conceptual planning stages for a hotel with retail space to be built on the site of an existing town-owned parking lot. Currently, the town has issued a Request for Proposals. The developer would be expected to replace the public parking spaces with a parking structure, which would be built above the town lot at Center Street. In addition, the developer would be required to provide parking underground at the site of the hotel. The town would like to see traffic mitigation in the form of a set of signals at the intersections of Harvard Street at Webster Street and Longwood Avenue. It is hoped that the signals will be coordinated with the Beacon Street system.

Hearthstone Plaza

10 Brookline Place West: 100,000 square feet of office space, 270-car garage, to be built on the air rights over the MBTA Green Line tracks.

Brighton

Brighton Avenue Reconstruction Project

Brighton Avenue once contained tracks for the "A" Branch of the Green Line. The city of Boston reconstructed Brighton Avenue between Cambridge Street and Commonwealth Avenue to remove the tracks and improve safety and traffic operations in the corridor. Traffic signals were upgraded or installed at five intersections. Left-turn bays, neck-downs, wheelchair ramps, interconnect cabling, streetscape architecture, and ornamental lighting were installed. Union Square was redesigned to change the channelization at the intersection. Median reductions, openings, and closures were built to better manage the flow of traffic in the corridor and to facilitate operations of the fire station in Union Square. Upon completion, Brighton Avenue had four 11-foot lanes, two in each direction separated by a 6-foot median, with 10-foot left-turn lanes at major intersections. Parallel parking and 10-foot sidewalks now exist on both sides of Beacon Street. This project has been completed.

Commonwealth Avenue Segment "B" Reconstruction Project

The city of Boston and MassHighway are planning a reconstruction of Commonwealth Avenue from its intersection with Brighton Avenue (Packard's Corner) to its intersection with Warren Street for the purpose of improving the safety and efficiency of the corridor, while enhancing its physical appearance. Construction would realign the MBTA Green Line tracks from the north side of the Commonwealth Avenue main line to the median of the main line. Commonwealth Avenue would then have two lanes in each direction and single-lane service roads on each side of the street. Improvements to landscaping, street lighting, and traffic signals, along with roadway resurfacing and sidewalk reconstruction, would contribute to the enhancement of the streetscape along Commonwealth Avenue. Project elements include provision of left-turn lanes at signalized intersections, upgrade of traffic signals with state-of-the-art equipment, installation of trolley-detection and trolley priority equipment at signalized intersections, and construction of wheelchair ramps at all crosswalks. The project would be constructed in conjunction with the MBTA Key Stations Project, which will reconstruct selected Green Line stations, including the station at Harvard Street, for compliance with ADA regulations. This project is in the design stage (TIP Appendix 020805, State Subcommittee phase 1).

Boston 400

The Boston Redevelopment Authority (BRA) is directing Boston 400, the city of Boston's new comprehensive planning process, shaping the public realm to best serve Boston's economy, families, and cultural institutions and to preserve Boston's legacy as one of America's most livable cities. The BRA will assess Boston's current condition, analyze the impacts of current projects, and develop and prioritize other complementary initiatives and implementation strategies. Its goals will focus on strengthening the infrastructure, and enhancing the streets and sidewalks,

parks and open spaces, residential and commercial districts, schools and public buildings, industrial areas and centers of entertainment.

A series of "Community Focus" planning meetings held in the neighborhoods in the spring of 1998 gave people who live or work in Boston a chance to contribute their visions and perceptions of the city. The participants at the Allston and Brighton meetings expressed strong interest in plans for improvements to the environmental design of the transportation infrastructure. They stated that streetscape redesign should include:

- Repairs of the cracked and unsafe sidewalks;
- Installation of information kiosks, maps, public rest rooms, landscaping, street furniture, bicycle facilities, trash receptacles, recycling bins, and bus shelters;
- Consolidation of the number of newspaper dispensers and billboards that clutter the environment in Allston-Brighton.
- A comprehensive strategy for the use of public art to illustrate the history of the neighborhood.

Participants noted three areas within the bus route corridor that were of particular concern:

- Harvard Avenue – Residents feel unsafe on Harvard Avenue due to insufficient lighting and would like to see existing light fixtures restored and new ones installed. They would like to see better enforcement of restrictions against double-parking and advocate installation of new parking meters.
- Cambridge Street at Lincoln Street – Residents perceive needs for better lighting, trash receptacles, and a posted bus schedule at the Cambridge Street bus stops on the bridge over the Massachusetts Turnpike.
- North Beacon Street, Brighton Avenue and Cambridge Street Intersection – In Union Square, local residents feel overwhelmed by traffic; crosswalk signals are not set long enough for children, elderly, and handicapped pedestrians. Residents would like the city to enhance the space to the east of the Jackson Mann school with outdoor furniture and possibly a bus shelter.

Transportation Plan and Access to Charles River

Participants expressed strong interest in Boston 400 producing a comprehensive transportation and land use plan that addresses concerns about commuter traffic, mass transit, access to the Charles River, air rights development, and mixed-use development in nearby communities. The issues participants wanted addressed include:

- Massachusetts Turnpike Exit – The Turnpike is perceived as a source of nuisance parking from people whose ultimate destination is Harvard Square in Cambridge but who park their

vehicles, sometimes all day, on nearby Allston-Brighton streets. Traffic impacts, neighborhood isolation, pollution, and noise from the Turnpike are also at issue.

- Truck Routes – Residents perceive a lack of clarity with respect to truck route policies and are concerned about trucks driving 'recklessly' through their neighborhoods due to a lack of knowledge of the truck routes. Participants want the plan to clarify where the truck routes are and include a signage program for marking them.
- Intersections with Poor Levels of Service and Pedestrian Safety Issues – Participants want a traffic management plan to reduce the amount of converging traffic, address intersections with poor levels of service and pedestrian safety issues (particularly at intersections with Commonwealth Avenue), and incorporate traffic-calming measures to protect pedestrians from the automotive environment. Residents would like traffic control improvements at all major intersections especially those most affected by the Turnpike commuters.
- Public Transportation Access – Residents desire improved access to public transportation and development of more cross-town service. Improvements to the reliability of the existing local bus service, better definition of bus stops, and posting of bus schedules at the bus stops are all on the public agenda. There is also interest in reinstating the commuter rail station and stop proposed at the Sports Depot in Allston-Brighton. Participants suggested that there be improvements made to frequency and reliability of the "B" branch of the Green Line and that the service hours be extended. The participants perceived a need for large-scale redesign of the branch, as well.
- Parking Lots and Illegal Parking – A shortage of parking in Brighton business districts leads commuters and business owners to park their vehicles all day in local neighborhoods to be closer to transit and businesses, often taking valued spaces from retail customers, and residents. Double-parked cars and commercial vehicles routinely block traffic, adding to levels of frustration for residents. Participants cited a need for enforcement of parking regulations, construction of a new public parking facility, and installation of parking meters to alleviate the double-parking problem.
- Bicycle Services - Bicyclists all over the city perceive a great need for parking and bicycle facilities. Participants want the plan to identify locations for installation of new bicycle racks and bicycle travel lanes.
- Emergency Services – Due to physical constraints that isolate North Allston, the area between Cambridge Street and Western Avenue, from the rest of Brighton, residents perceive a need for a satellite emergency facility with a couple of fire engines and an ambulance.
- Conrail Freight Yard and Romar Transportation Yard – There is interest in redevelopment strategies for the Conrail freight and Romar transportation yards, including creation of a new industrial park and new open space.

Metropolitan District Commission

Charles River Master Plan

Draft; Goody, Clancy and Associates, Rizzo Associates - The Metropolitan District Commission is in the process of drafting a master plan for the Charles River Basin which describes the existing conditions and identifies and prioritizes restoration needs and enhancement opportunities. The primary focus of the plan is preserving the historical and recreational character of the river basin, while improving the experience of pedestrians, bicyclists, and boaters. Some of the potential recommendations affecting the Route 66 study area include:

- reinforcing the parkway character of Storrow Drive, Soldiers Field Road, and Memorial Drive,
- adding curbing and parkway trees to Soldiers Field Road and Memorial Drive,
- restoring and protecting the open grassy character of the riverfront near the Weld Bathhouse and Weeks Bridge,
- removing one westbound lane of traffic on Memorial Drive west of Sparks Street to widen the parkland,
- re-aligning the sidewalk ramps at the intersection of Memorial Drive and JFK Boulevard to meet the crosswalks.

Cambridge

Winthrop Park

Under construction; 100–102 Mount Auburn Street, 91–93 Winthrop Street; Eliot Square Enterprises.

Wursthaus Redevelopment

Under construction; 1380, 1384–1392 Massachusetts Avenue, 6–8 and 10–14 JFK Boulevard; Cambridge Savings Bank.